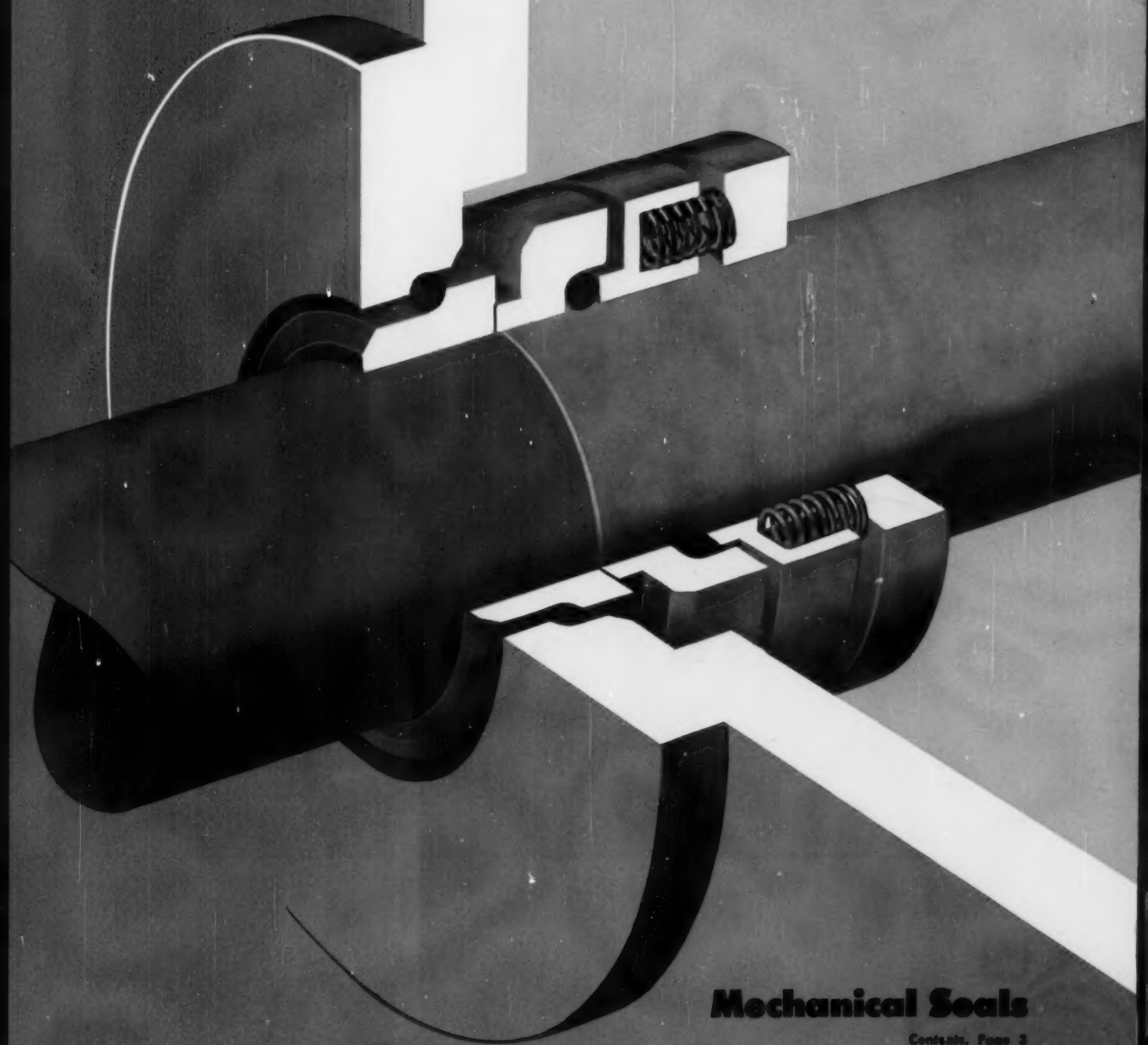
MARCH 3, 1960

MACHINE DESIGN

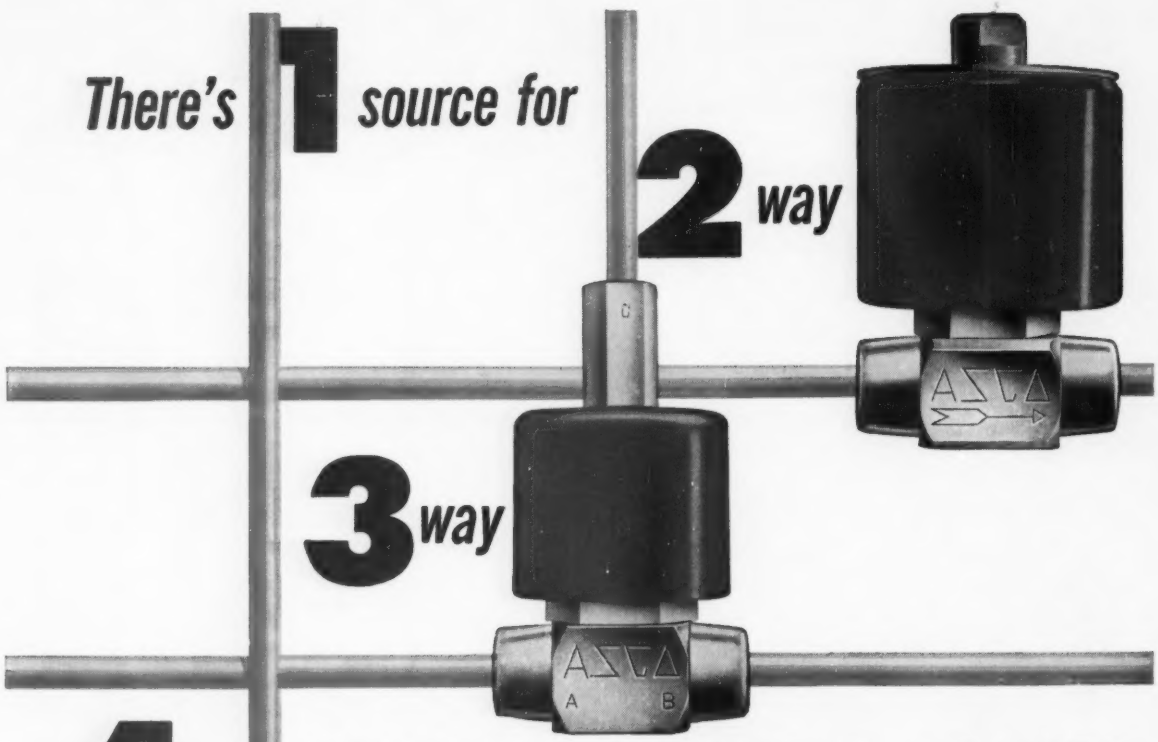
A PENTON PUBLICATION — BIWEEKLY



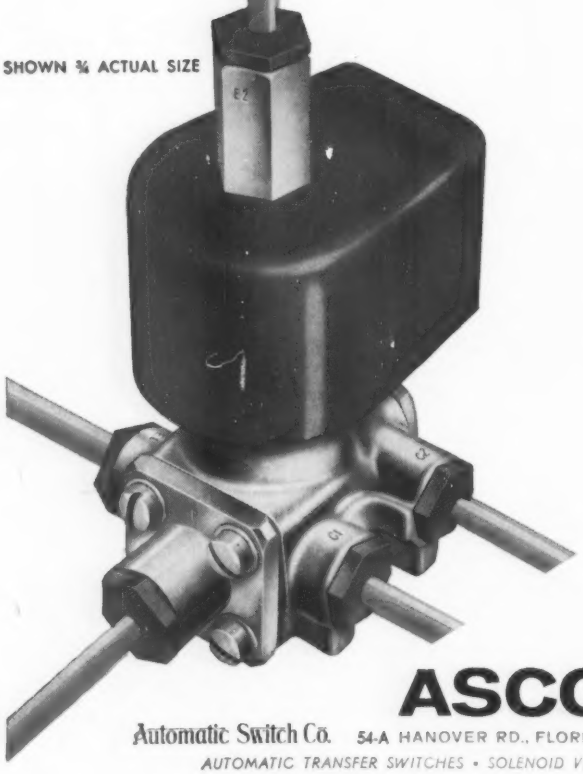
Mechanical Seals

Contents, Page 3

There's 1 source for 2 way 3 way or 4 way MIDGET SOLENOID VALVES



SHOWN ¾ ACTUAL SIZE



World's largest stock of solenoid valves for industrial applications available for immediate delivery.

Send for Publication No. 506, Stock list and valve selection guide.

ASCO Valves

ASCO®

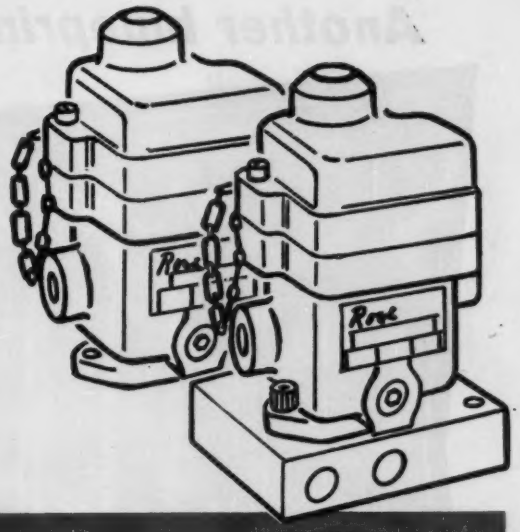
Automatic Switch Co. 54-A HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

Circle 401 on Page 19

The Ross PACER gives you 56 new solenoid air valves

The Ross PACER is a fine new solenoid valve in the ⅛" and ¼" size range that gives a full $\frac{5}{32}$" flow capacity yet uses only 7 watts of holding power. The PACER is built for especially long life yet is priced surprisingly low. Capable of 1000 cycles per minute and more, is JIC, and very light and compact. And if you're interested in large valves the PACER has a second identity, that of a pilot section to actuate *any* valve of the Ross Skyline series. It will operate any of these valves at top speed and with low power consumption.

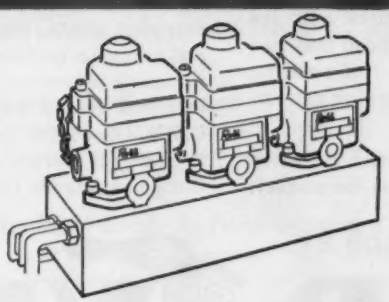


As well as being a complete new valve

...PACER is also a new pilot section in the Ross Skyline valve series...

	PIPE SIZES						
COMPLETE PACER VALVES	⅛"	¼"	⅜"	½"	¾"	1"	1¼"
STRAIGHTWAY, N/C	√	√					
3-WAY, N/C	√	√					
4-WAY	√	√					
SKYLINE VALVES USING PACER AS ACTUATOR (HEAD)							
STRAIGHTWAY, N/C		√	√	√	√	√	√
STRAIGHTWAY, N/O		√	√	√	√	√	√
3-WAY, N/C INLINE MT.		√	√	√	√	√	√
3-WAY N/O, INLINE MT.		√	√	√	√	√	√
3-WAY, N/C, BASE MT.		√	√	√	√	√	√
3-WAY, N/O, BASE MT.		√	√	√	√	√	√
4-WAY, INLINE MT.		√	√	√	√		
4-WAY, BASE MT.		√	√	√	√	√	√
4-WAY, 5-PORT		√	√	√	√		

New **PACER** manifolds to save piping and wiring



Ross manifolds provide a compact and economical method of multiple mounting PACER valves. One air supply line and one electrical conduit can serve all PACER valves. Manifolds are available in two and three stations.

STAY AHEAD

MODERNIZE

ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

Circle 404 on Page 19

Another blueprint of better design–

–and a new idea in shock dampening!

Absorbing the crashing impacts between 120-ton freight cars was a tough job for even the heaviest of helical steel springs. So this big railroad equipment-maker decided to investigate the possibilities of rubber in designing a new kind of coupling draft gear.

The Goodyear experts then went to work with the equipment manufacturer's engineers. Soon they had come up with a new rubber compound of amazing toughness – molded it into shock-absorbing rubber-to-metal sandwiches, nine to a set.

Result: a new draft gear that provided far more impact-protection than anything else on the market. Its recoil, for example, was only 18% – a low never reached before. It was, in fact, the first draft gear of its type ever to be approved by the railroad lines' own certifying agency.

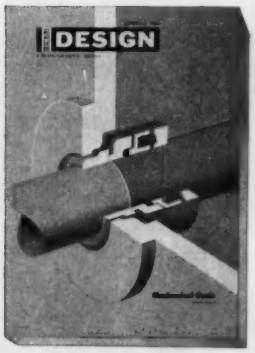
Credit another success, then, to the resourceful technicians, in the well-equipped Goodyear molded/extruded plants, who have solved shock absorption and vibration problems in a wide range of equipment for many industries. To talk over your own molded/extruded rubber requirements – contact your local G.T.M.–Goodyear Technical Man. Or write directly to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED OR EXTRUDED GOODS BY

GOODYEAR

THE GREATEST NAME IN RUBBER

Circle 405 on Page 19



Front Cover: Mechanical seals, as shown on George Farnsworth's cover design, aren't supposed to leak—or wear. But they do. Methods of minimizing these problems are covered in Ehrhard Mayer's article on Page 106.

March 3, 1960

Medical Engineering 24

MITCHELL SABANAS—*News Report*—Medical and engineering professions combine efforts to meet a vital challenge: Duplicating human subsystems with man-made hardware.

Mistreatment Engineering 29

E. L. POWELL and J. J. COONEY—*News Report*—Torture tests of shipping containers in packaging research show where design changes are needed for product improvement.

Convertible Engineering Organization 98

GEORGE FRIED—How to meet the organizational changes required for efficient handling of big projects as they advance from conception to completion.

Leakage and Wear in Mechanical Seals 106

EHRHARD MAYER—What can be done to reduce seal leakage and wear: Causes of leakage and wear, leakage-rate calculations, recommended design practices.

Tapping Screws 114

LOUIS OEST—Practical factors that influence the selection and application of the different standard screw types to meet specific design requirements.

Positioning Cams 121

F. R. E. CROSSLEY—A simplified numerical procedure for evaluating and modifying cam profiles to reduce follower chatter and increase service life.

Simplified Vibration Analysis 134

AUSTIN H. CHURCH—*Part 2: Single-Degree-of-Freedom Systems*—Three general methods for solving vibration problems in the simplest types of linear mechanical systems.

Visualizing Gas Flow 142

R. F. ANDERSON and T. F. RASKE—*Tips and Techniques*—Two quick methods for obtaining an easy-to-see picture of the flow pattern in gases.

Plastics for Extrusions 143

ROBERT MARX—*Data Sheet*—Physical properties, service characteristics, and application comparisons for the most common types of extrudable plastic materials.

Transient Loads in Fluid Systems 148

LEE B. EDDY—*Design Abstracts*—Typical moment-of-inertia values and speed-torque characteristics of centrifugal pumps and compressors.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

March 3, 1960
Volume 32 — No. 5

Qualified to Design 97
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Torture tests for tires 6
Mach-3 machining 6
Powdered polyethylene 8
Saturn tankage 10
Engineering enrollment down 10
Automatic transistor line 12
Truck-back turbines 12
Semiconductor strain gage .. 27
NSPE backs pay raises 32
DOD Plastics Data Center .. 34
PDQ light trucks 36
Automatic map selector 39

Trends 22
Meetings and Shows 40

Scanning the Field for Ideas 102

Geneva drive with built-in barrel cam provides interrupted indexing—one-piece rubber valve controls fluid flow—coarse-thread power screw shifts torque-transmitting discs to change transmission speeds—movable air inlet controls flow of fluid at pump discharge—rolled capacitor permits miniaturization without loss of efficiency.

Design in Action 127

Clock balance-wheel oscillation produces reciprocal motion to generate electrical signal for recording—rotating blades scrape off sticky contents in ore car—moire fringe bands measure increments in linear motion—plastic pipe delays sound for mechanically produced echo.

Tips and Techniques

Trigonometric functions . 113
Preventing ink spreading 147

Design Abstracts 148

New Parts and Materials 158

Engineering Department Equipment 180

The Engineer's Library 183

Noteworthy Patents 186

Backtalk 198

Helpful Literature 153

Subject Index 17
Reader Service Cards .. 19
Business Staff 197
Advertising Index 197

IN THE NEXT ISSUE: Coarse or fine threads? . . . flexible printed circuits . . . hydraulic swivel systems . . . roller-bearing life . . . simplified vibration analysis . . . low-temperature properties.

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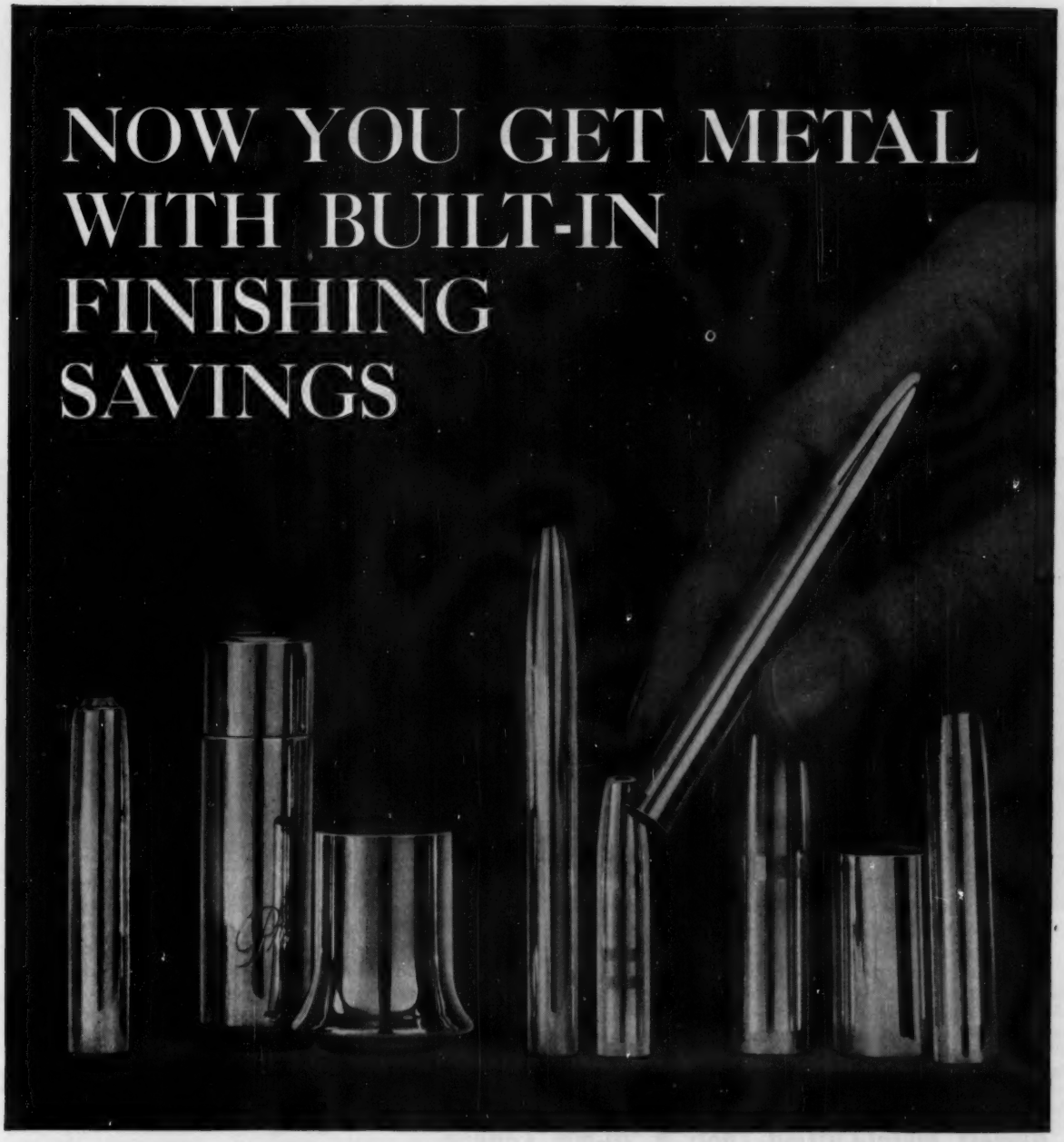
NOW YOU GET METAL WITH BUILT-IN FINISHING SAVINGS



Faster production and up to 40% cut in polishing costs are made possible by superfine-grain structure of Formbrite® Drawing Brass

The jeweler's finish which Accurate Forming Corp., Franklin, N. J., gives pen caps and barrels previously meant the use of five polishing heads and a time bottleneck in production—resulting in a high polishing "cost factor." After switching to Red Brass-Formbrite, they use two polishing heads for a light cut and another for a simple color buff and run the machines faster. Savings run up to 40%. The secret of Formbrite is its superfine grain, produced by special rolling and annealing techniques. Formbrite is springier, harder, more scratch-resistant than the usual drawing brasses in the same standard tempers, yet retains remarkable ductility for forming and drawing. Despite its superiority, *Formbrite costs no more than ordinary drawing brass.* Get full details from your Anaconda representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

FORMBRITE

SUPERFINE-GRAIN DRAWING BRASS AN

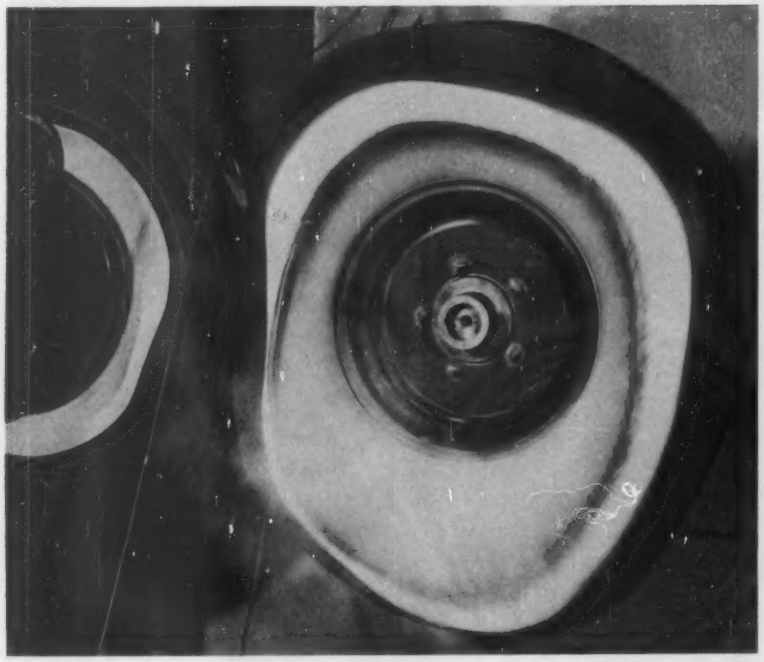
ANACONDA®

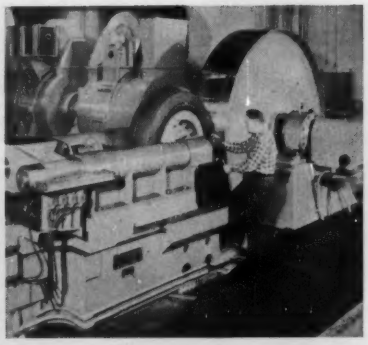
product made by The American Brass Company

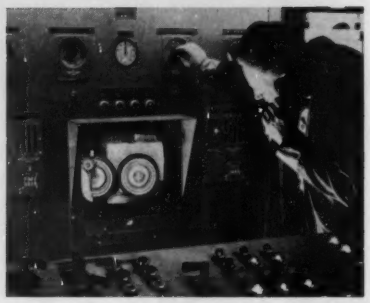
Circle 406 on Page 19

ENGINEERING NEWS

Torture Tests for Tires (at 510 mph)







Fastest rotation ever recorded for a tire—510 mph—is no strain for a test rig built by Goodyear Tire and Rubber Co., Akron. A new multistage dynamometer rotates tires at super speeds to prove they are reliable for jet aircraft and the fastest racing cars. Goodyear's engineers are able to duplicate all of the operational conditions of taxiing, take-off, and landing—even the impact, yawing, and twisting of an airplane tire as it touches down on a runway. Knowledge gained will also result in improved passenger-car tires, reports a company spokesman. Engineers have tried standard auto tires on the machine and none of them failed at less than 297 mph. On one unit, there is a "tire-on-tire" facility. Two tires are pressed together, tread to tread, to duplicate actual load conditions. Here surface speeds often exceed 500 mph. A second unit features a 10-ft flywheel with a tire carriage on each side. Used primarily for testing airplane tires, the flywheel is capable of surface speeds of 320 mph.

Newest Metal-Cutting Tool: A 20-mm Cannon

Mach-3 Machining May Cut Costs Of Future Supersonic Transports

BURBANK, CALIF.—Using a 20-mm cannon, engineers at Lockheed Aircraft Corp. are cutting high-strength steel and titanium alloys at machining velocities of 250,000 surface feet per minute. This is more than 16 times faster than cutting speeds now used for aluminum and more than 6000 times faster than speeds used on hardened steel and titanium.

Before Lockheed's investigation of super-speed machining, it was generally believed that metals possessed critical impact velocities and would fail if that velocity were passed. Laboratory and field tests, however, indicated machining speeds could be greatly accelerated without harming the material being cut.

Results to date show these advantages for the Lockheed technique:

- Improved surface finishes.
- Prolonged life of cutting tool.
- Lower temperature at tool face.

A modified 20-mm gun fires the workpiece (projectile) past a tool fastened to a special extension of the barrel. Workpieces vary from 1¾ to 12 in. in length, and are propelled with standard 20-mm hand-loaded cartridges. When the type and weight of powder charge and the weight of the projectile workpiece are varied, cutting speeds ranging from 15,000 to 250,000 surface feet per minute are obtained. A bunker filled with Celotex sheets catches workpieces unmarred.

Materials tested include AISI 43400 steel, AM 350, Inconel "X," 6A1-4V titanium and 7075-T6 aluminum, all in the fully hardened condition.

Standard ⅜ and ½-in. square cutting tools made of conventional

. . . Fluid Power news

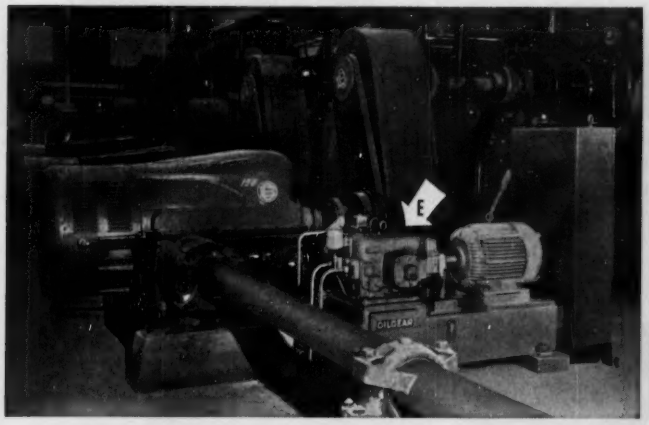
REPORT No. 12,104 OILGEAR SOLVES SPEED CONTROL PROBLEM

From Oilgear Application-Engineering Files

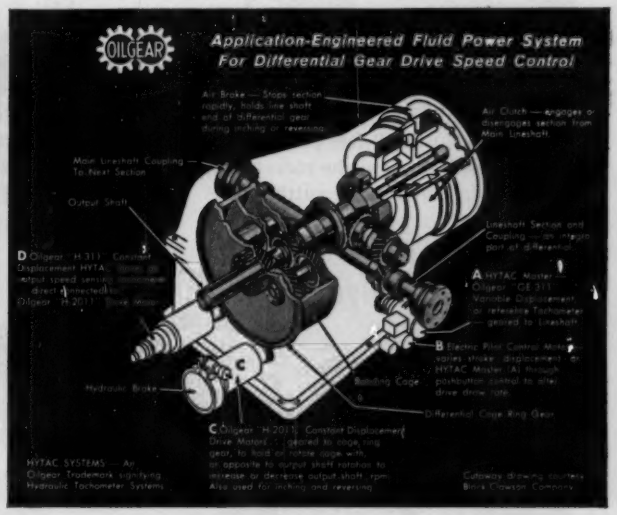
HOW HYTAC SYSTEMS CONTROL DIFFERENTIAL DRIVE SPEEDS ON NEW 190" PAPER MACHINE

USER: *Sonoco Products Company, Hartsville, South Carolina*
BUILDER: *The Black-Clawson Company, Inc., Paper Machine Division, Watertown, New York*

DATA: To design and build a differential-type drive, Black-Clawson engineers outlined the following over-all requirements: 1. To be rugged, simple, and have easily replaceable parts. 2. Speed variation device to control sizes from 150 to 1200 hp, and be capable of performing additional functions — inching, reversing, and slack take-up. 3. Device must maintain synchronous speed regardless of load or temperature changes. 4. Complete drive must be compact, clean design • After solution of gear mechanism problems, the following additional requirements were outlined for the speed variation system: 1. Simple, remote, section control panels, with all controls interlocked. 2. Draw range of at least ±4½%, precisely variable. 3. Must be capable of 24-hour continuous drive service with an absolute minimum of maintenance. 4. Would prefer one source, one responsibility for entire control system. (Mechanical, electrical, and hydraulic systems were investigated.)



A portion of Sonoco Products Company's new "Mr. Mac" — 190" (170" trim) Black-Clawson paper machine designed to produce 9-pt., semi-chemical corrugating board at speeds up to 1500 fpm. "Mr. Mac" is the first paper machine to be fully equipped with differential gear drives on which speed is hydraulically controlled and operated. Three of these new Oilgear Fluid Power Controlled, Black-Clawson differentials are shown above with one of the accompanying Oilgear "Power-Paks" clearly visible. These drives are used on the couch roll, first press, second press, first dryer section, breaker stack, second dryer section, calendar stack, and "autoflyte" reel . . . a total of 8 drives—5 rated at 150 hp, 3 rated at 300 hp.


OILGEAR
Application-Engineered Fluid Power System
For Differential Gear Drive Speed Control
Air Brake — Stops section rapidly, holds line shaft end of differential gear during inching or reversing.
Air Clutch — engages or disengages section from Main Lineshaft.
Main Lineshaft Coupling To Next Section
Output Shaft
Lineshaft Section and Coupling — an integral part of differential.
D Oilgear "H-311" Constant Displacement HYTAC output speed sensing motor, direct connected to
Oilgear "H-2011" Drive Motor
A HYTAC Master Tachometer Source — (CE 311) Variable Displacement or reversible Tachometer geared to Lineshaft
B Electric Pilot Control Motor varies stroke displacement of HYTAC Master (A) through pushbutton control to alter drive draw rate.
Hydraulic Brake
Bolding Cage
Differential Cage Ring Gear
C Oilgear "H-2011" Constant Displacement Drive Motors — geared to cage ring gear, to hold or rotate cage with or opposite to output shaft rotation to increase or decrease output shaft rpm. Also used for inching and reversing.
HYTAC SYSTEMS — An Oilgear Trademark signifying Hydraulic Tachometer Systems
Cutaway drawing courtesy Black-Clawson Company

SOLUTION: Application-Engineered *HYTAC SYSTEMS* arranged through teamwork between Oilgear and Black-Clawson engineers throughout the stages of design, testing, application, and actual installation.

Black-Clawson states — *"operating characteristics highly important to any papermaking machine are obtained through a unique hydraulic motor differential cage drive and a HYTAC SYSTEM (hydraulic tachometer feedback control arrangement). Significant features of this HYTAC drive are: 1. Machine sections can be inched or reversed with line shaft running or down. 2. No helper motors needed — no belts or chain drives involved. 3. Accurate speed regulation. 4. Precision draw control for all applications — 9% draw range. 5. HYTAC SYSTEM maintains speed regardless of load or temperature changes. 6. Hydraulic mechanism and control panels can be located remotely from drives. 7. Complete drive control interlocked. 8. Load on machine sections indicated by pressure gages on drive. 9. Compact, durable construction. 10. Absolute minimum of maintenance required."* The reasoning that led to selection of HYTAC SYSTEMS has also been clearly stated by Black-Clawson engineers, as follows: *"Mechanical drives had many serious drawbacks, such as horsepower limitations and the inability to perform the desired functions. Choice between electric or hydraulic drive proved more difficult . . . necessity that electronic controls circuits would be required to maintain accuracy, and the larger size of the driving units were the deciding factors in favor of the hydraulic drive. To determine size, an analysis was made . . . here again hydraulic drive proved its superiority, since the drive motor could be driven in both directions. Tests proved that the drive was even more accurate than our original expectations . . . regulation between zero and rated load was only ±0.005%. Under conditions of constant load and speed, a variation of ±0.002% could also occur . . . when added together, maximum regulation is ±0.007%."*

Circle 407 on Page 19

HOW IT WORKS: Fluid from lineshaft-driven master tach (A) gives differential drive speed command to control on Oilgear "DRX-2011" two-way, variable displacement pump (E), indicated in photo, left, of Oilgear "Power-Pak" installation. Slave tach (D) feeds back a flow signal proportional to actual differential drive speed. When main lineshaft speed increases or decreases, fluid flow from Master Tach (A) automatically increases or decreases correspondingly to command differential drive to follow lineshaft speed change. Through local or remote pushbutton stations connected to electric pilot motor (B) on Master Tach (A), operator can increase or decrease speed of each section infinitely up to 9% of prevailing lineshaft speed. When differential cage is rotated with, or in same direction as the output shaft by motors (C), output shaft speed is increased. If cage is rotated in the opposite direction by motors (C), output shaft speed is decreased. All factors, such as change in load or temperature, are automatically compensated by these HYTAC SYSTEMS to maintain exact, set degree of section synchronization with lineshaft at all times.

Accurate synchronization of multiple, tandem operations; combining separate operations to handle webs or sheets — soft, fragile at one point — strong at another; or continuous webs when tension affects quality . . . all need more than conventional drives and controls . . . they need the precision of HYTAC SYSTEMS, or other Oilgear "Any-Speed" drives and controls!

For practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY
Application-Engineered Controlled Motion Systems
1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

high-speed tool steel are used. Each cutting tool is used only once to establish a direct comparison between tool wear, cutting speed, and metallurgical change.

Mile-Long Tool Bed

After hundreds of tests in Lockheed's laboratory facilities, additional tests were conducted at Edwards Air Force Base, where a rocket-sled run was used to test a workpiece too large for indoor "firings." In these experiments, the workpiece is mounted to the sled; the cutting tool is held stationary between the rails. A maximum velocity of 1080 feet per second (approximately Mach 1) has been achieved.

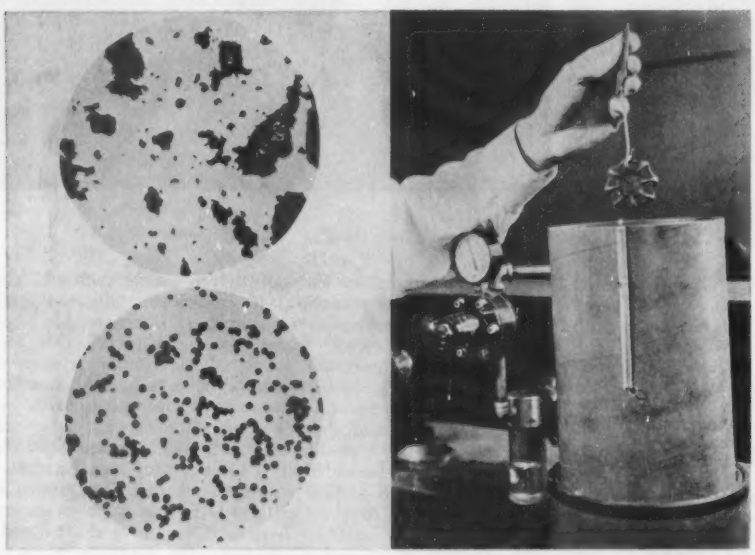
In comparing cuts made with a conventional tool room planer operating at 40 to 80 feet per minute, the 20-mm gun, and the rocket sled, researchers have found cutting conditions to be identical, except for speed.

Results of long cuts (4 ft) made on the supersonic sled track compared closely to those obtained from projectile tests made with the 20-mm gun, engineers reported. They concluded that increasing tool cutting time by a factor of eight had no effect on the result.

In both indoor and outdoor tests 120,000 ft per minute proved to be the best machining speed for minimum tool wear on AISI 43400 steel. No upper limit for machining speed was established.

According to J. B. Wassall, Lockheed's director of engineering, 20-mm machining represents one of many new production techniques which must be adopted if manufacturing capabilities are to keep pace with design advancements. He expects the new cutting technique to be used in building the next round of commercial jet aircraft.

Powdered Polyethylene



European successes have spurred U. S. Industrial Chemicals Co., New York, to develop powdered polyethylene for American industry. In Europe, the product has found many applications—it protects metals from corrosion and is an additive in waxes and auto polishes. Other uses include liners for tanks and drums, stiffeners and binders for textiles and fabrics, and coatings for wire, glass, and paper. USI will produce two types: One, a solution-produced material, will boast a particle size smaller than 75 microns (200 screen mesh), lower left; the second will be made up of larger, mechanically ground particles ranging in size from 75 to 300 microns (200 to 50 screen mesh), upper left. Advantage of the powder is that it can be applied inexpensively. After being dispersed in water or alcohol it can be sprayed; dry powder can be applied directly to a heated object, or the object can be dipped in a fluidized bed (right). Irregular shaped objects are easily coated, and larger moldings are possible with the powder than with other polyethylene forms.

Topics

Portable pub in Great Britain dispenses whiskey and soda or whiskey and water when a thirsty customer inserts the equivalent of 35 cents in a slot. Time locks on the vending machine keep it law-abiding, permitting it to serve only during the proper hours. Meanwhile, here in the colonies, vending machines—even those that offer less exotic products—are doing a $2.2 billion annual business. Meals account for nearly 10 per cent of the take, with about 1.7 million coin-droppers ordering at least one slot-machine meal a day.

• • •

Analyzing tobacco combustion like an electronic instrument should, a mass spectrometer made by Bendix Aviation Corp. checks chemical reactions that occur in smoke, at a rate of 10,000 analyses per second. The University of Uppsala in Sweden is seeking to discover hitherto unknown facts concerning the physics and chemistry of tobacco combustion; the spectrometer makes such study possible because of its ability to instantly identify vaporized gases, liquids, and solids by revealing their molecular masses.

• • •

Sonic booms will be welcome in Glacier National Park this spring—their vibrations will disperse piles of snow that threaten to cause avalanches. Convair F-106s will fly over the park in "Operation Safe Slide."

• • •

Radioactive water that goes down into the earth will come up pure, according to a proposal for the disposal of these wastes. The idea is to pump water-carried radioactive waste into sandstone layers below the point of contamination danger to water, oil, coal, or minerals. Field test results show that waste would stay in the sandstone; pure water would return to the surface.

• • •

Computer begets computer, saving at least six months of engineering and design time from original ideas of system design through testing of the first prototype. A Minneapolis-Honeywell Datamatic 1000 electronic data processing computer is playing a big part in designing, engineering, and supplying manufacturing instructions for its successor, the solid-state transistorized Honeywell 800. One time-saver was substitution of lists of tables and symbols on magnetic tape for some 10,000 electrical circuit drawings. The new model, announced early in January, is being promised for October delivery.

For the engineer who refuses to stagnate

HALF the world is half asleep! Men who could be making *twice* their present salaries are coasting along, hoping for promotions but doing nothing to bring themselves forcefully to the attention of management.

They're *wasting* the most fruitful years of their business lives . . . throwing away thousands of dollars they may never be able to make up. And, oddly enough, they don't realize—even remotely—the tragic consequences of their failure to forge ahead while time is still on their side.

Engineers and other technically-trained men are particularly prone to "drift with the tide" because their starting salaries are reasonably high and promotions come at regular intervals early in their careers. It isn't until later—too much later in many cases—that they discover there is a definite ceiling on their incomes as technicians.

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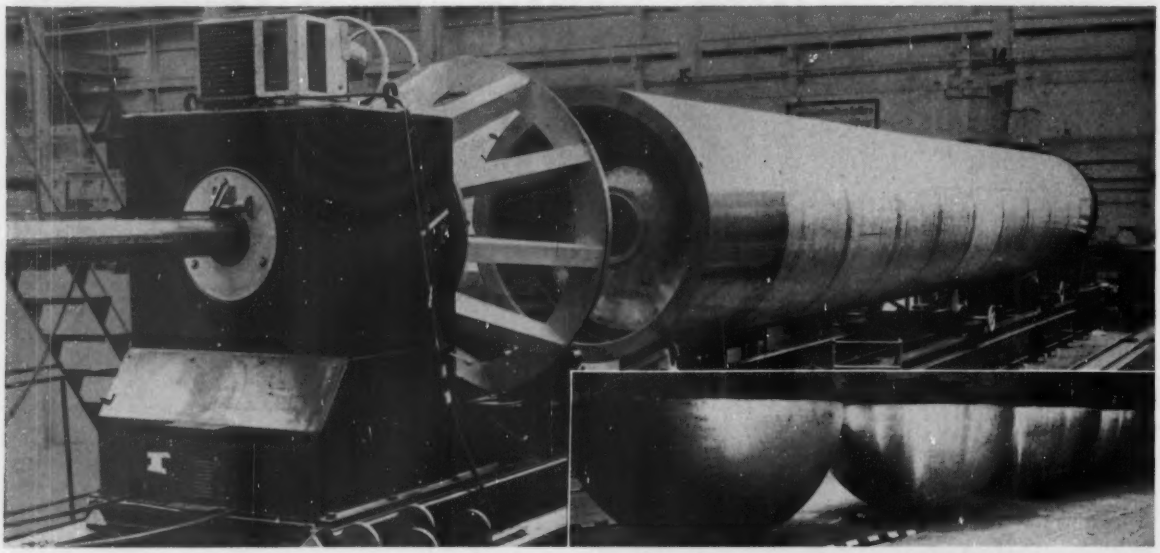
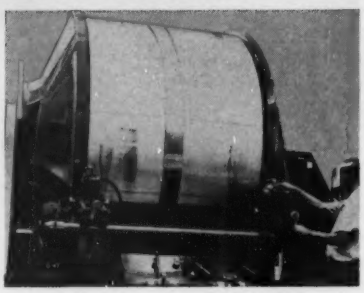
Saturn Tankage Takes Shape





Nine fuel and oxidizer tanks, included in the first (booster) stage of NASA's 1.5 million-lb-thrust Saturn space vehicle, are in final stages of fabrication at Army's Ballistic Missile Agency, Huntsville, Ala. Most of the hundreds of tons of LOX required for the eight-engine booster will be carried in a 105-in. diameter, 60-ft long modified Jupiter fuel tank (above). Eight modified Redstone tanks (right) containing fuel and additional LOX encircle the central oxider tank. Spun aluminum bulkheads (insert) form the oxidizer and fuel compartments in these 70-in. diameter Redstone tanks. Aluminum composition chosen for the rigorous Saturn application is alloy 5456, developed by Aluminum Company of America, and recognized as the strongest of the highly weldable aluminum-magnesium series. Almost 11 tons of 5456 aluminum sheet are used in the fuel tanks. Forgings, also of 5456, form weldable fittings and attachments.

Downswing Continues in Engineering Enrollment

Manpower Shortage Predicted During "Growth Years" Ahead

URBANA, ILL.—Enrollment in America's accredited engineering colleges has dropped for the second consecutive year. This fall 240,063 students registered in engineering, compared to 249,950 in 1958, and 257,777 in 1957.

On a percentage basis, total engineering enrollment in the fall of 1959 was down 4 per cent from '58 and 6.9 per cent from '57, according to the survey. These decreases came at a time when total college enrollments were rising by 10.9 per cent during the two-year period. In 1959, engineering students accounted for only 7.1 per cent of all college students, compared with the high of 8.4 per cent in 1957.

These figures, compiled by the U. S. Office of Education, come from 154 engineering schools in the United States and are assembled each year under a joint survey conducted by ASEE (American Society of Engineering Education) and the U. S. Office of Education. The survey covers all engineering colleges with one or more engineering curricula accredited by the Engineers' Council for Professional Development.

According to B. R. Teare, Jr., ASEE president, "This continued decrease in enrollment, and particularly the decrease in freshmen, is a matter of great concern to all of us. Studies by the Engineering Manpower Commission indicate not only that the demand for engineers is increasing, but also that it is expected to accelerate. Our ability to expand the production of consumer goods to satisfy the requirements of our multiplying population depends upon a large and increasing supply of well educated engineers. In addition, they are needed for our space exploration program, the development of ballistic missiles, and of other weapons of defense. The demand from all of these sources for more engineers will increase in future years, and will have to be met by the students presently enrolled in engineering schools and by those who will enroll in the next few years. If the industrial growth of the country and the defense programs are not to be impaired, the trend of the last two years must be reversed. Furthermore, every time there is a readjustment of business activity, the press and the general public should not cry "wolf" and thus discourage students from undertaking the study of engineering."

Engineering enrollments for advanced degrees continued to show increases in the fall of 1959, but the

CASE HISTORIES

N/D integral rolleron gyro wheel and shaft with precision instrument ball bearing solves sidewinder reliability problem. Actual ball bearing O.D. measures little more than an inch.

N/D Designs Reliability Into Sidewinder Rollerons!

CUSTOMER PROBLEM:
With ever-increasing speeds of new fighter aircraft, the rollerons of this aircraft-fired missile failed because they were subjected to environmental conditions more severe than those for which originally designed.

SOLUTION:
New Departure engineers in conjunction with Naval Ordnance Test Station solved the problem by recommending a simplification of the original rolleron assembly. An integral gyro wheel and shaft was designed that maintains critical rolleron reliability. What's more, the new design reduces inventories, assembly time and inspections. And today, this same N/D creative engineering and reliability can be found in more than twenty of America's major missiles . . . in airframe, guidance, propulsion and ground support.

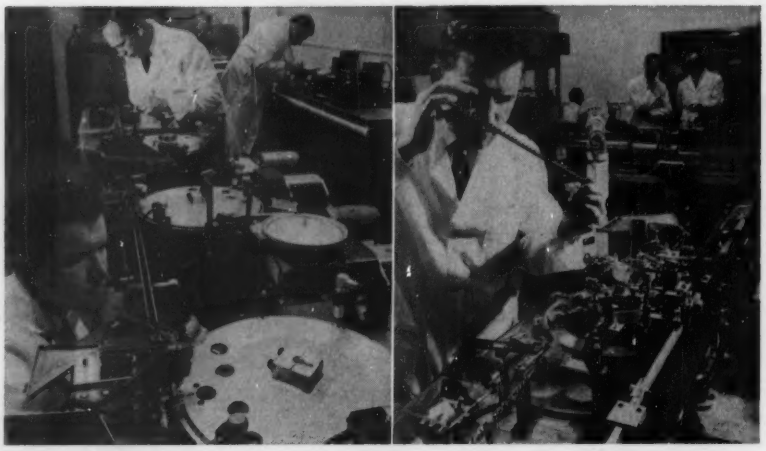
If *your* product has unusual ball bearing demands, call in a New Department Sales Engineer. He's armed with a complete line of Miniature, Instrument and standard ball bearings . . . one that's sure to do the job for you! Write Dept. L.S., New Departure Division, General Motors Corporation, Bristol, Conn.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

Circle 409 on Page 19

rate of growth is decreasing. A total of 34,731 graduate students (in engineering) were enrolled in 1959-60: 28,734 were registered for master's degrees, 357 for professional degrees, and 5640 for doctor's degrees. This represents a 6 per cent increase in master's and 18.4 per cent increase in doctor's registrants over the previous year.

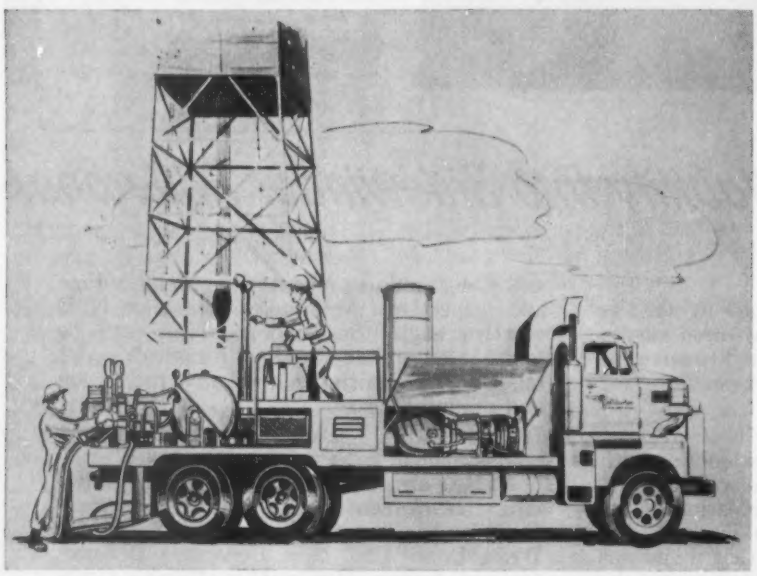
"The continued increase in postgraduate enrollment," Dean Teare stated, "is reassuring, but if undergraduate numbers continue to decrease, it is obvious that the urgently needed growth of graduate enrollment cannot be expected. The demand for quality is even greater than for numbers, in industry, in government, and especially in educational institutions. The supply of qualified young men to strengthen present faculties is still the greatest problem in engineering education," according to Dean Teare.



NPNs by the Thousands

A miniature assembly line is automatically turning out NPN transistors at an 1800 per hour rate. Developed by International Business Machines, the system is made up of six turntables, two ovens (for alloying and bonding), and a welding unit. These nine units (joined by conveyors) fabricate transistors from preformed parts—emitter and collector dots, germanium discs, base tabs, whisker-like wires, and mounting bases. Photocells coupled to mechanical rejectors throw out transistors that can't pass inspection. IBM says the 500 sq ft machine has the highest output of any existing automatic method for transistor production.

Truck-Back Turbines

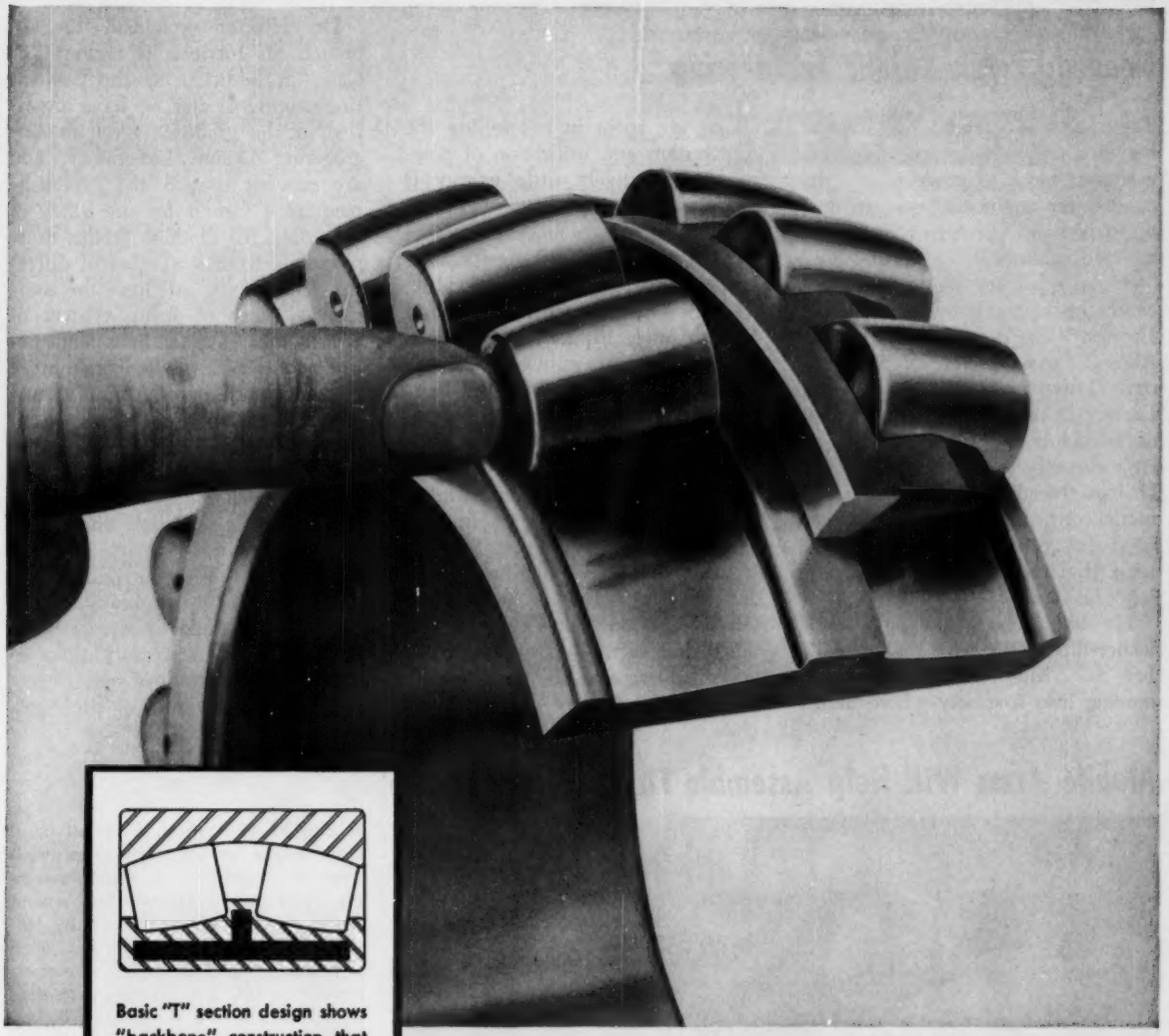


Size of the Powerplants

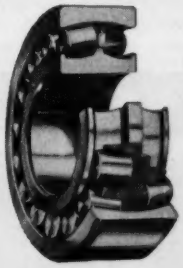
	Model 240	Model 720/722
Rating (shaft hp)		
max 5-min rating	20,500	...
max continuous	18,300	900
Weight (lb)	5450	300
with reduction gears	.....	1200
Dimensions (in.)*		
length	214-269	85
width	84-59	...
height	79-95	40

*Varies for Model 240, depending on the application. For Model 720/722, dimensions include gearing.

A new lightweight gas-turbine family boasts high power-to-weight ratio and compact size. Developed by General Electric, Schenectady, N. Y., the turbines are based on proven jet-engine powerplants. They are intended for jobs where mobility and small size are key parameters; their outputs range from 50 to 20,000 shaft hp. Two models are currently available. Model 240, rated at 20,000 hp, incorporates the basic gas generator used on GE's J79 military engine. In one version, the unit will furnish electric power for auxiliary or emergency purposes. It's available in a complete generating package mounted on a 48-ft long trailer for mobility (right). Output of the unit is 7500 kva of 60 cycle power. Model 720/722 (722 burns natural gas, 720 burns liquid fuels) is a 900-hp unit that is designed around the T58 turboshaft engine. The smaller unit is undergoing field testing as a drive for an oil-well fracturing unit (left). Other applications predicted for the turbine family—several new sizes with different horsepower ratings will be available in the near future—include powerplants for high-speed hydrofoil boats, emergency power sources for distressed areas, and mobile field-operated generators for the military.



Basic "T" section design shows "backbone" construction that insures positive roller guidance and stability without skewing under all load conditions.



For roller stability...

there's nothing like "the bearing with the backbone"

The only *positive* way to guide rollers is by an integral center guide flange—backbone of the *Torrington* Spherical Roller Bearing. No floating ring can match it for stability under heavy radial and thrust loads.

This "bearing with the backbone" insures true rolling motion . . . prevents stress concentration . . . means minimum friction. It makes possible open-end cage design, too, with no shrouds to impede circulation of lubricant to bearing contact surfaces. There is less heating and more positive lubrication.

The integral center guide flange is adapted from the same principle used in the design of Torrington Tapered Roller Bearings. This refinement is typical of Torrington's uncompromising engineering that assures you the ultimate in bearing performance. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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Circle 410 on Page 19

Needed: Triple-Threat Engineering

CLEVELAND — Traditional barriers between engineering specialties are a serious block to progress . . . the need is for engineers who can deal with complex problems involving many disciplines.

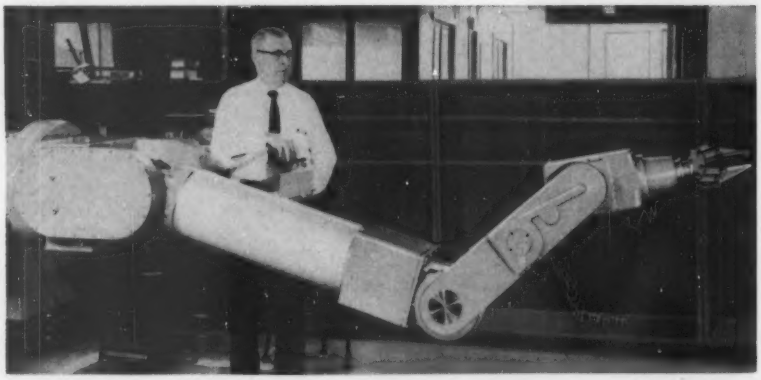
These were key points made recently in a speech by Dr. John A. Hrones, Vice President for Academic Affairs, Case Institute of Technology. Delivering the James Clayton Lecture before England's Institution of Mechanical Engineers—one of engineering's greatest honors—Dr. Hrones traced the history of automatic controls, stressed the world's need for relieving able minds of tasks that can be handled in some other fashion.

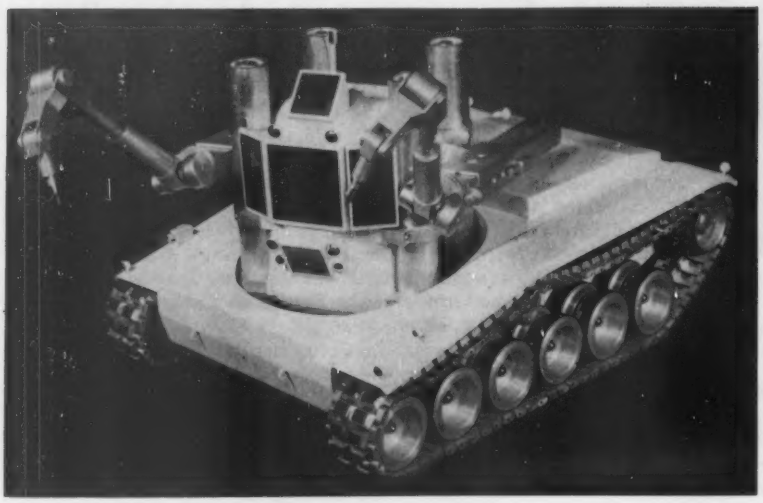
He said, "The world sadly needs leadership of the very highest caliber . . . More and more we are moving into a society where man's efforts are spent in controlling the distribution and utilization of power, and relatively little energy is directly supplied by man. If the western world is to maintain a position of influence and to continue its traditional support of individual freedom, talented men must be used to their fullest capacity in situations where judgment, wisdom, and creativity are indispensable. We must therefore develop our understanding of control phenomena."

In discussing the future of automatic control, Dr. Hrones stressed the importance of design. He said, "Design in the sense that I use it is the creation of something which did not previously exist. It is a total job from conception—through detailed delineation—to successful operation. Design in its fullest meaning is the top role of the engineer."

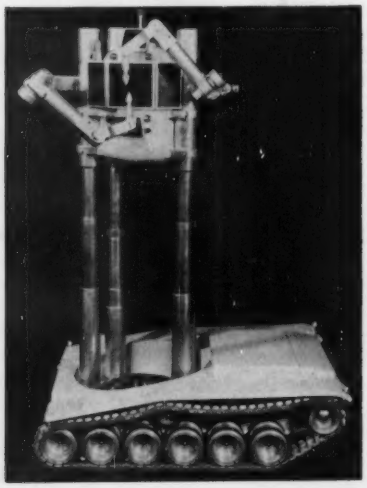
Dr. Hrones explained the approach his Institute is taking: "At Case, in addition to the Systems Engineering Center we have organized at the graduate level an Engineering Design Laboratory, and are moving toward the establishment of a Center for the Study of Materials. All of these groups draw personnel from a number of different departments. All have the common element of being centers of professional investigations and developments of a challenging nature which require knowledge and understanding in more than one of the traditional fields of engineering and science. In addition to great emphasis on the development of analytic skills there is being developed a continuous stream of design throughout the entire educational program at Case. Imaginatively executed and sparked by the presence of outstanding design work, this element is the feature which clearly distinguishes the role of the engi-

Mobile Arms Will Help Assemble First Nuclear Engine





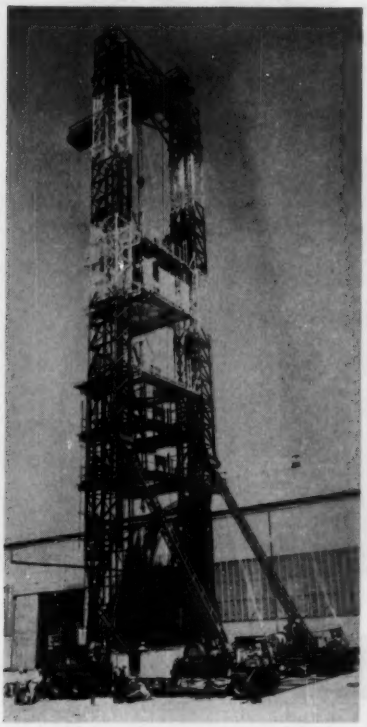
A pair of 18-ft arms, mounted on a crawler-type vehicle, will keep engineers at a safe distance during assembly and servicing of forthcoming nuclear-aircraft engines. Built by Mechanical Div., General Mills Inc., each arm can lift and delicately maneuver more than 100 lb while fully extended. In addition to the usual dexterity expected from a mechanical arm—shoulder rotation, shoulder flex, elbow bend, wrist rotation, and grip—the General Mills model is gifted with wrist bend, elbow rotation, and telescoping upper arm. Mounted on the crawler, arms and operator adjust readily to working heights (below).



neer from that of the scientist.

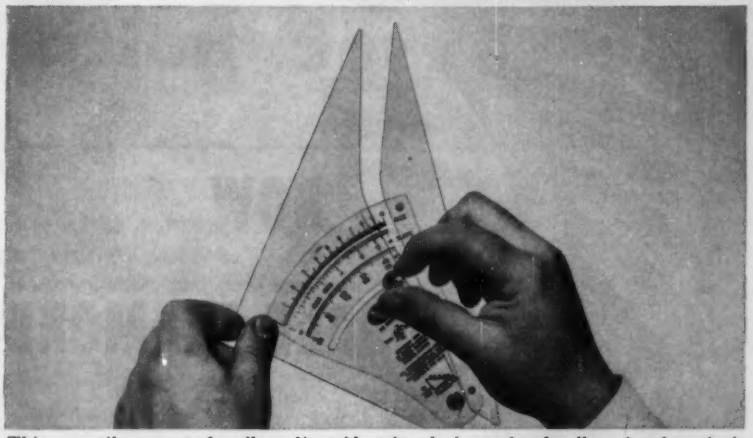
"In the design of the complex controls systems, the engineer must be able to cope with electrical as well as mechanical phenomena. He must utilize the most powerful tools of computation as they may be required. This is a large order. It requires an extended program of graduate work and associations with faculty members who are engaged in actual design work of the very broadest and imaginative nature."

Traveling Missile Base



A 150-ft tall mobile missile gantry, believed to be the tallest and heaviest tire-mounted structure in the U. S., has been developed for Redstone and Jupiter-class missiles. Designed and built by Noble Co., Oakland, Calif., the portable pad weighs 350,000 lb and is mounted on two six-wheel trailers. Outboard rear wheels of the trailers are electric-motor driven. The tower structure includes six adjustable service platforms, two elevators, two crane hooks, and complete power-generating equipment. An emergency system, activated by the push of a panic button, slides the service platforms back from around the missile, retracts trailer jack pads, and moves the tower away from the missile. The entire structure can be stacked on its trailers for ground or air transport.

DRAFTING TRENDS



This versatile, easy-to-handle, adjustable triangle is made of yellow-tinted optical-grade acrylic plastic. A clean-cut oval track fitted with metal knurled knob assures ease of operation and lasting tight fit.

New combination protractor-triangle speeds up drafting

Architects, Engineers, Builders, Field Surveyors, Mathematicians—anyone who develops solutions to measurement problems indirectly to determine a wanted measurement graphically or mathematically—will find the Trig-Matk Adjustable Triangle a handy tool. It eliminates much of the graphic work necessary in estimating results or in checking for correct answers.

Versatility with accuracy

Basically the new Post Trig-Matk Adjustable Triangle is a mathematician's tool—accurate to three decimal places.

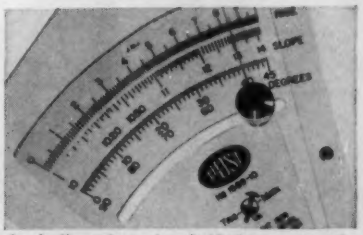
It combines the functions of a protractor and a triangle into a simple unit, with two fundamental trigonometric relationships of a right triangle. The Trig-Matk provides accuracy within 0.1% in problems dealing with any of the six trigonometric ratios of the sides of a right triangle.

The adjustable protractor has three sets of graduations. One set is graduated in half degrees, labeled *Degrees*, and permits the use of the Trig-Matk as a protractor setting for determining any angle from 0 to 90 degrees.

The second set of graduations, labeled *Slope*, shows directly the *Secant* trigonometric ratio of the angle indicated on the degree scale. The third scale, labeled *Rise*, indicates directly the *Tangent* trigonometric ratio shown on the degree scale.

Examples

This new tool has a host of drafting and engineering applications. Highway designers find the Trig-Matk very useful when making cross sections of roadways at ground level or below. By



An indicated angle of 40 degrees on the Trig-Matk (1589) shows directly that the Rise is 8.4 to the base of 10.

setting the *Slope* scale to the degree desired, road-curve grades are automatically determined. The protractor can be used to determine the angle of highway ingress and egress lanes.

Structural Engineers will find the Trig-Matk Adjustable Triangle a simple tool, eliminating the use of both a scale and individual triangles. In addition to the time saved, many of the errors usually associated with the older method are avoided. The Trig-Matk design eliminates the need of frequent reference to handbooks for information on various bevels.

Two Bases

The Trig-Matk No. 1589-12 has a 12" base scale for handy calculation in terms of feet and inches. Number 1589-10 has a metric base scale of 10.

Keep posted on all the latest trends in drafting. Consult your local Post *dealer, or write to Frederick Post Co., 3652 North Avondale Ave., Chicago 18, Ill.*

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†REG. U.S. PAT. OFF.

Circle 412 on Page 19

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SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Accumulators, Adv. 183, 189

Actuators, Adv. 27

Adhesives, Adv. 183

Airplanes, Edit. 22

Aluminum and alloys, Adv. 37, 185

Amplifiers, Edit. 177

Atomic energy, Edit. 22, 23

Axles, Adv. 74

Bearings,
- ball, Edit. 160; Adv. 11, 61, 80, 88, 171, 174, 189
- needle, Adv. 73
- roller, Adv. 13, 72, 78, 88
- sleeve, Adv. 171

Belts, transmission, Adv. 95, 164

Blowers, Adv. 34

Books, Adv. 183

Brass (see Copper and alloys)

Bronze (see Copper and alloys)

Brushes, commutator, Adv. 175

Cams, Edit. 121, 158

Capacitors, Edit. 105

Caps, Adv. 195

Carbides, Adv. 199
- cemented, Adv. 87

Castings,
- investment, Adv. 152
- iron, Adv. 71, 162, 169
- nonferrous, Adv. 180
- steel, Adv. 94

Chain, transmission, Edit. 179

Clamps, Edit. 163; Adv. 192

Clutches, Adv. 195

Coatings,
- decorative, Adv. 54
- protective, Adv. 35, 54, 156

Cold heading, Adv. 81

Computers, Adv. back cover

Controls,
- electric, Adv. 48
- hydraulic, Edit. 105

Converters, Edit. 177

Conveyors, Adv. 86

Copper and alloys, Adv. 5

Counters, Edit. 161; Adv. 191

Couplings,
- fluid flow, Adv. 174, 178
- shaft, Edit. 158; Adv. 51

Cylinders,
- hydraulic, Edit. 175, 186; Adv. 46, 79, 92 152
- pneumatic, Edit. 175; Adv. 152

Drafting equipment, Adv. 15, 33, 42, 156, 194

Drafting techniques, Edit. 113, 147

Drives, adjustable speed, Adv. 177, 178, 193

Electric equipment (see specific type)

Electronic equipment, Edit. 23, 27, 132, 164, 168, 181; Adv. 48, 190

Engineers, Edit. 26

Engineering department (see Management or Drafting)

Engineering organization, convertible, Edit. 98

Engines, Adv. 45

Fans, Adv. 59

Fasteners,
- bolts, studs, screws, Edit. 158; Adv. 75, 83, 91, 188
- insert, Adv. 157, 172
- nuts, Edit. 167; Adv. 62, 66, 83, 181
- quick operating, Edit. 166; Adv. 60, 96
- rivet, Edit. 172; Adv. 66, 157

Finishes (see Coatings)

Fittings, pipe, tube, and hose, Edit. 169; Adv. 79

Fluid flow analysis, Edit. 142

Gages, (see also Instruments)
- pressure, Adv. 64

Gaskets, Adv. 67

Gear shaping, Adv. 182

Gears, Adv. 16, 65, 151, 190, 193, 195, 196

Heaters, Adv. 160, 176

Hydraulic equipment (see specific type)

Instruments, Edit. 130, 180

Knobs, Adv. 191

Latches, Adv. 193

Lighting, Edit. 162; Adv. 188

Lubricants, Edit. 151

Lubrication systems, Adv. inside back cover

Materials, Edit. 176; Adv. 154

Materials handling equipment, Edit. 128

Medical engineering, Edit. 24

Meetings, Edit. 40

Metals (see specific type)

Mistreatment analysis, Edit. 29

Motors (electric)
- fractional and integral hp, Edit. 166; Adv. 28, 69, 84, 90, 150, 163, 167, 192
- subfractional hp, Adv. 30, 84, 170
- synchronous, Adv. 30

Motors,
- hydraulic, Edit. 186
- pneumatic, Adv. 76

Mountings, vibration and shock, Adv. 2

MACHINE DESIGN is indexed in the Applied Science & Technology Index and the Engineering Index, available in libraries, generally. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

Plastics, Edit. 34, 36, 143, 170; Adv. 56, 82, 93
laminates, Adv. 56, 82, 200
molding, Adv. 58

Plugs, Adv. 195

Pneumatic equipment (see specific type)

Potentiometers, Edit. 167, 171

Power supplies, Edit. 180

Pumps,
hydraulic, Adv. 85, 150, 170, 173
pneumatic, Adv. 187

Recorders, Edit. 127

Rectifiers, Edit. 151

Reducers, speed, Adv. 168, 189

Regulators, pressure, Adv. 63

Relays, Adv. 52, 155

Rotary joints, Edit. 186; Adv. 166, 191

Rubber, Adv. 2, 51

Screws, power, Adv. 104
tapping, Edit. 114

Seals, Adv. 41, 67
mechanical, Edit. 106

Shapes, special, Adv. 47

Small parts, Adv. 192

Stampings, Adv. 190

Steel, Adv. 165
stainless, Adv. 40, 179

Switches, Edit. 163, 170, 174; Adv. 48, 52, 77, 161, back cover

Systems, hydraulic, Edit. 148; Adv. 7

Terminals, Adv. 196

Thermostats, Edit. 158; Adv. 70, 196

Timers, Adv. 184

Transistors, Edit. 23

Tubing, Adv. 21, 44, 89

Universal joints, Adv. 159

Valves,
hydraulic, Edit. 103, 161, 172, 176, 179, 187; Adv. inside front cover, 39, 46, 50, 186, 188, 192
pneumatic, Edit. 178; Adv. inside front cover, 1, 39, 50, 188

Vehicles, Edit. 36

Vibration analysis, simplified, Edit. 134

Wire and wire products, Adv. 40

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

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Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 153

	ITEM NUMBER
Industrial Plastics	601
Hose Fittings and Hose	602
X-Y Recorder	603
Subminiature Valves	604
Vibrating Feeders	605
Electrical Resins	606
Toggle-Switch Assemblies	607
Diesel Engine	608
Multichannel Plotters	609
Laminated Plastics	610
Mercury Thermostats	611
Welding Fittings and Flanges	612
Canned Pumps	613
Switches and Terminals	614
Eddy-Current Coupling Drives	615
Digital Volt-Ohmmeter	616
Servo Motors	617
Metalworking Processes	618
Fastener Selection	619
Subminiature Connectors	620
Breadboard Components	621
Insulated Thermocouples	622
Proximity Limit Switch	623
Explosion-Proof Housings	624
Stainless-Steel Tubing	625
Lock Nuts	626
Cast-Bronze Alloys	627
Flexible-Shaft Assemblies	628
Butterfly Valves	629
Control Panels	630

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 158

	ITEM NUMBER
Instrument Cams	631
Overtemperature Protector	632
Flow Indicator	633
Flexible Couplings	634
Self-Sealing Screws	635
Ball Bearings	636
Pressure-Balancing Valves	637
Photoelectric Scanner	638
Miniature Glow Lamps	639
Plastic Sockets	640
Band Clamp	641
Proximity Limit Switch	642
Tunnel Diode	643
Rubber Clips	644
Universal Motors	645
Trimming Potentiometer	646
Spring-Steel Nuts	647
Reflector-Type Pickup	648
Ball-Bearing Slides	649
Descaling Nozzles	650
Magnesium Boxes and Covers	651
FEP Fluorocarbon Resin	652
Snap-Acting Switch	653
Precision Potentiometers	654
Zone Control Valve	655
Blind Rivets	656
Proximity Switch	657
Solenoid-Operated Cylinder	658
Servo Indicators	659
Sheet Packing	660
Ball Valves	661
Transistor Amplifier	662
Analog-Digital Converter	663
Air-Control Valve	664
Roller Chain	665
General-Purpose Valve	666
Strain Compass	667
Power Supply	668
Time-Delay Generator	669

MACHINE DESIGN
March 3, 1960

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
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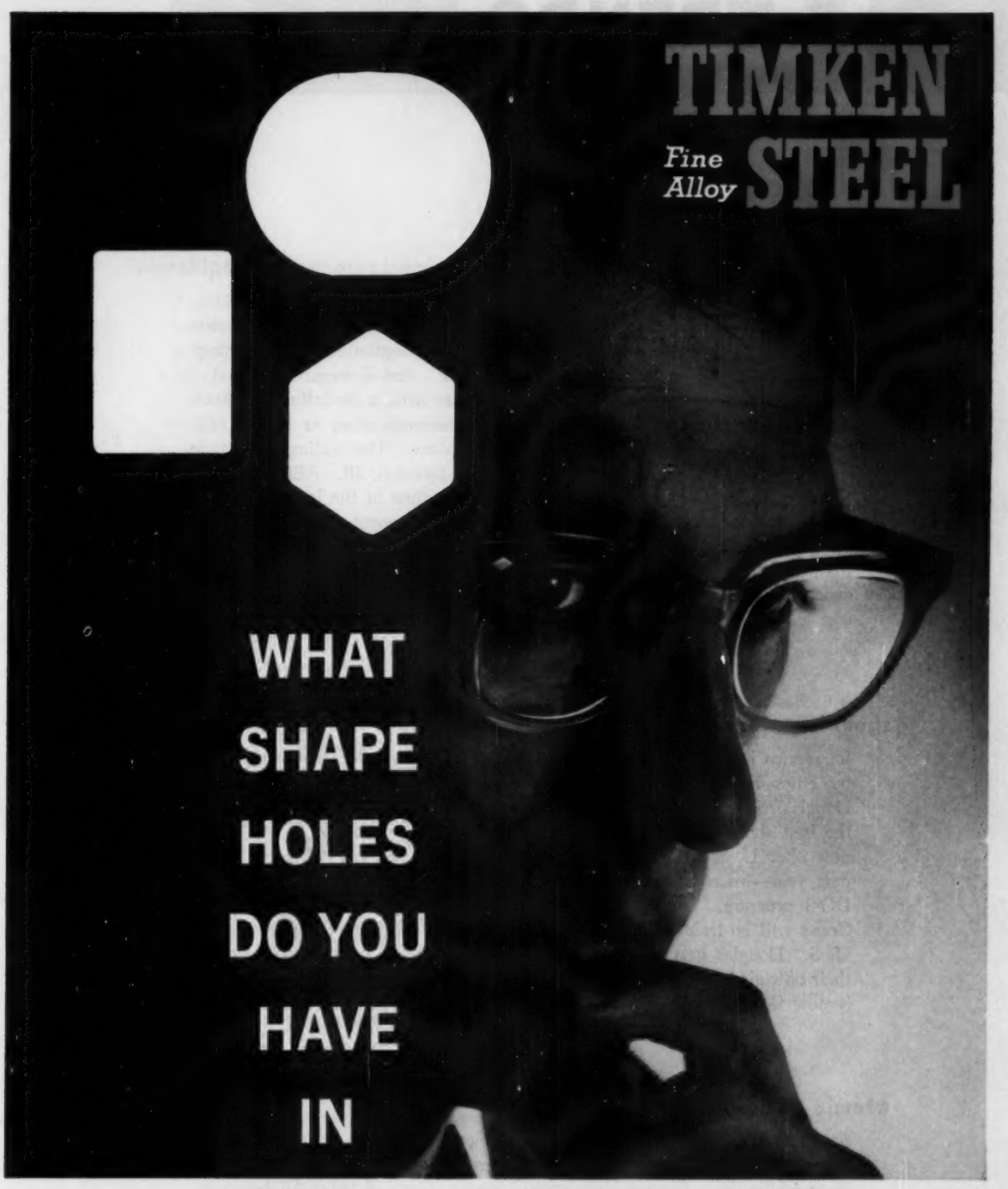

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Circle 413 on Page 19

NEWS TRENDS

AEC sets ten-year deadline

A turning point in the U.S. atomic-power program may be in the making. In a special report to Congress, AEC has disclosed that Southern California Edison Co. and Pacific Gas and Electric Co. are negotiating with Westinghouse Electric Corp. (pressurized-water reactor) and General Electric Co. (boiling-water reactor) to construct two plants with a capacity of 300,000 kw each. The pressurized-water reactor is currently used in atomic submarines and in the Shippingport, Pa., powerplant. The boiling-water type is being installed in the 180,000-kw plant at Dresden, Ill. AEC chairman John A. McCone pointed out that "for the first time in the long and sometimes discouraging history of nuclear power development, utilities can consider the construction of these large plants on a purely economic basis, rather than as a long-range developmental project." He said the two plants would generate electricity at an estimated cost of about 8 mils per kwh. Present cost in California is 7 mils per kwh.

short-hop jets

Jet service between New York and Washington (200 miles) and other nearby cities may arrive sooner than expected. France's Sud Aviation and Douglas Aircraft have teamed up to make and sell the Sud Caravelle—called the best short-range plane now available by some authorities. Douglas can now offer U. S. airlines a jet designed for short hops that can be delivered next year—instead of in three or four years had they continued with their DC-9 program. Initial plans call for the aircraft to be built in France. Crews will be trained, spare parts manufactured, and aircraft serviced in the U. S. Douglas gets manufacturing rights, but before production is started, their officials intend to wait and see how many orders come in. The Caravelle is now flown by about 60 foreign airlines.

atomic boilers: off the shelf soon?

Atomic energy as a boiler heat source is not as visionary as it might seem, says R. E. Emrich Sr., president of Boiler Engineering & Supply Co. Inc., Phoenixville, Pa. Custom-built atomic energy plants of today all have central-station heat-exchange equipment designed by boiler manufacturers, and advances in miniaturization will bring the atomic-fired boiler to the small industrial, commercial, and institutional market sooner than most of us realize. Boiler manufacturers are interested in three approaches to the atom, he observes. The first—the conventional approach—is to generate electricity in a central atomic station. Then electric boilers would be indirectly atom fired. The second is to replace burner and furnace with a battery-like atomic charge. In this case, the boiler could be like present-day boilers. The third possibility is that heat from central atomic plants could be transferred to a working fluid and the fluid piped to customers. A liquid-to-water heat exchanger would be necessary in a boiler of this type.

warships get an electronic ganglion

A new central monitoring system oversees all the electronic devices on a naval vessel. When any component fails or begins to operate marginally, a trouble-pinpointing signal is relayed to a display console and preventive maintenance can be applied immediately. The system, developed by Stanford Research Institute, Menlo Park, Calif., allows the Navy's increasingly complex electronic equipment to be serviced by crews largely untrained in electronics.

phototransistors

General Motors Corp. has made its debut in the semiconductor field with the development of a cadmium sulfide field-effect transistor. Believed to be the first solid-state device of its type, the CdS transistor is unique in that its electrical properties are affected by light; e.g., amplification can be controlled by changing the color or intensity of light focused on the device. Conventional amplification at a fixed light level is also possible. Although still in the experimental stage, the phototransistor has been used successfully in oscillators, multivibrators, and amplifiers. According to GM researchers, the device is comparable in size to conventional solid-state units and demonstrates similar efficiency and ruggedness. Its output and input resistances are higher than normally encountered with junction transistors and vacuum tubes, the researchers explain, and coupling the device to other active circuit elements is difficult. Accordingly, use of the device as an amplifying element is presently limited to low-frequency applications requiring high impedance.

progress reported on 60-sec color film

Although they won't predict production dates, officials of Polaroid Corp., Cambridge, Mass., report substantial progress in developing a print-a-minute color film for the Polaroid land camera. Chief problem has been the synthesis of special color-forming reagents and other compounds necessary to the color process. Mastering the control techniques is reported to take the combined efforts of process engineers, equipment designers, and many other specialists.

thermoelectric power from the atom—prospects good

Specialists are now predicting that meaningful quantities of thermoelectric power will soon be generated from nuclear heat and radioactive decay. According to Westinghouse's S. J. Angello, rare-earth metals will soon boost operating limits of thermoelectric systems and nuclear-heat temperatures can then be put to work. Dr. Paul C. Aebersold, AEC's isotope development director, adds that a thermoelectric system powered by decay of strontium 90 radioisotopes will go into operation at Oak Ridge within a year. It will generate up to 100 w and use about 5 per cent of the strontium 90 emission. But within the next ten years, the 340-lb thermoelectric system will generate electricity matching the output of 125 tons of chemical storage batteries.

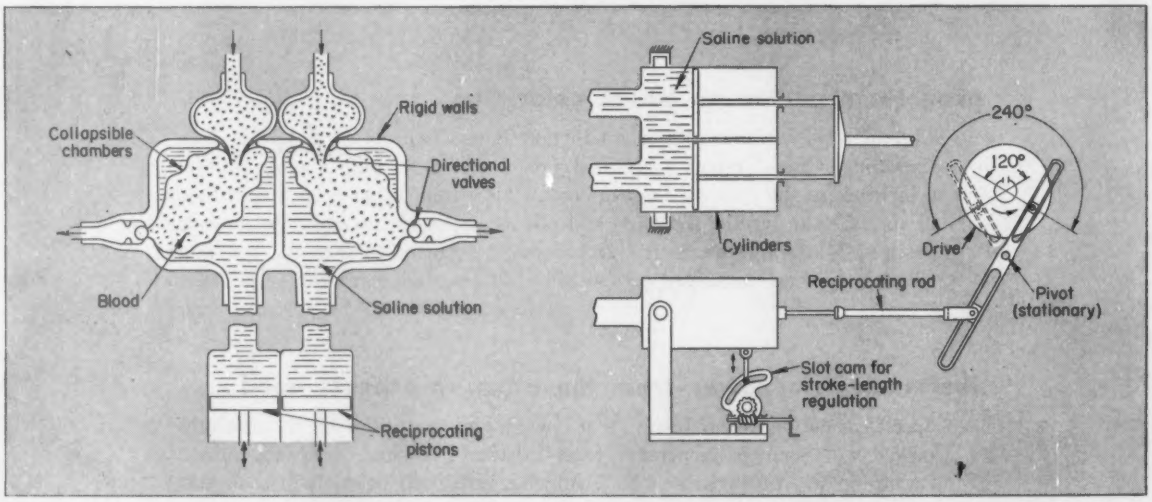
Medical Engineering . . .

is the suggested designation of a relatively new and exceedingly vital field of engineering . . . a field that desperately needs "new blood." The development of a heart-lung machine, described on these pages, is a typical M-E problem . . . and it serves to illustrate the natural compatibility of design engineering and medicine.

DUPLICATING human subsystems with man-made hardware frequently gives rise to one particular question: Does the mechanical componentry have to do the job in exactly the same manner as the human counterpart? The body, for example, can do without any number of its original parts—arms, legs, one lung, bladder, appendix, etc.—and the body also continues to operate at high efficiency after certain organs have become modified by disease or injury.

It is usually assumed, then, that a mechanical device that closely, but not exactly, duplicates the function of a human organ can at least keep things going on a temporary basis . . . this is the case with present heart-lung machines. The typical heart substitute is connected to the patient so that blood flows into an oxygenator and is returned to the body by a mechanical pump. Machines differ in design because no standards have been established, and because individual surgeons have certain preferences about details. The biggest difference is the method by which the blood is oxygenated. Some machines bubble the oxygen through the blood, while others spread the blood in a thin film over screens in an oxygen-filled chamber at proper temperatures. Virtually all the machines circulate the blood with one or two pumps, although in some arrangements, the oxygenator is placed lower than the patient and makes use of gravity to eliminate one pump and simplify controls.

In all heart-lung machines, the flow pulsates only slightly. There is no conclusive evidence as to the role that the pulse plays in the circulation of the blood. One explana-



Heart substitute, designed by scientists at Armour Research Foundation, more nearly resembles the mammalian heart than other similar machines. Major components are two plastic chambers analogous to the ventricles, and an actuator driven by an electric motor. The actuator, consisting of two pistons driven in tandem through a variable speed drive, is powered by a ¼-hp electric motor. Speed of the drive can be varied from 10 to 150 rpm. The rotating motion of the drive is converted into a reciprocating one by a linkage which maintains a 2:1 ratio of time for backstroke to time for forward stroke, regardless of magnitude or frequency of the stroke. Thus, blood is propelled into the body in one unit of time, but two units of time are required to fill the chambers. Blood volume in circulation is always proportional to length of piston stroke and frequency. It is possible to vary both piston stroke and frequency.

MITCHELL SABANAS
Research Engineer
Armour Research Foundation
Illinois Institute of Technology
Chicago, Ill.

tion is that no muscle can endure continuous stresses without damage. The filling or muscle rest period of the heart is approximately twice as long as the compression or work period, which seems to validate this theory. Since pulsating flow is the natural one, it is assumed that the body is adapted to such a flow, and that a permanent heart substitute might have to incorporate this feature. Because the media to be propelled is alive, component design and material selection problems are different from those encountered in any other hydraulic application. The blood is fragile and can be destroyed by rough handling. Blind spots which cause stagnation, directional flow valves, and abrupt changes in tubing diameter which may cause turbulent flow are avoided as much as possible. Shock and high pressure waves creating sudden positive or negative pressures are also undesirable. The degree of negative pressure created by the pumps is more significant in producing destruction of the blood cells (hemolysis) than the degree of positive pressure.

Another key consideration is the material that comes in contact with the blood. It must cause minimal chemical change. Synthetic materials have been found most satisfactory in this respect. The modern trend in blood perfusion equipment is toward expendable plastic materials because reusability is hindered by the difficulty encountered in sterile cleaning of blood and protein residues after use. The majority of blood circulation pumps are

HEART HYDRAULICS

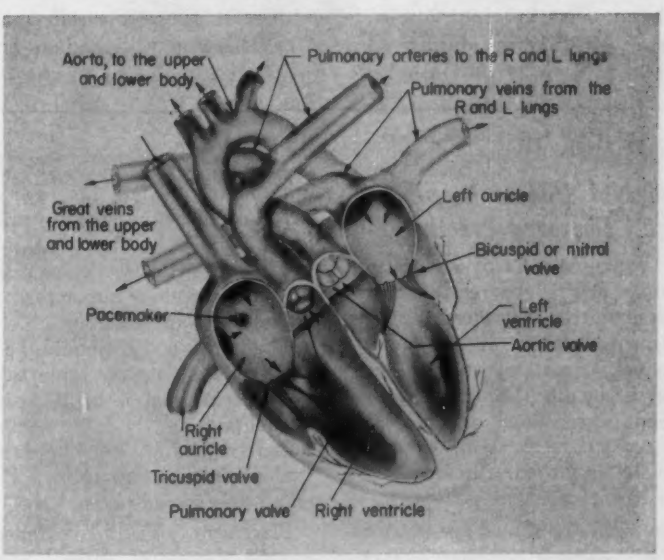
The heart is a delicate, yet durable, hydraulic pump with an efficiency unequalled by any machine. It makes use of unidirectional flow valves and bioelectric currents (which resemble servo-actuators) to power the most extraordinary hydraulic circuit.

The heart consists of two pumps separated by a blood-tight wall. Each pump handles the same volume of fluid, but at different pressures. Blood returns from the body tissues into the right auricle of the heart through great veins. It then passes through a directional valve (the tricuspid) into the right ventricle. When the heart muscle contracts, blood is forced out through the directional pulmonary valve and into the lungs. Average pressure in this pulmonary circuit is 1.6 psi.

Next, the blood picks up oxygen from the lungs and discharges its freight of carbon dioxide. Oxygenated blood returns to the other half of the heart through the pulmonary veins and enters the left auricle, then passes on through another directional valve (bicuspid or mitral valve) into the left ventricle. Here, the contracting heart muscle forces blood through another directional valve into the aorta and out to the whole body. The blood in this circuit finally reaches the tiniest arteries of the body. Pressure in this circuit is 2.4 psi.

Pressure generated by the heart is not the sole source of energy for blood delivery. It has been demonstrated that the pressure in the smaller vessels exceeds the pressure generated by the heart in the aorta, often by 100 per cent or more. This mysterious servo-pressure booster, comprised of various nerves is actuated when there is a demand for more blood.

A timing device called the "pacemaker" is responsible for the heart beat. The pacemaker, which generates bioelectric signals, is a small knot of tissue located in the wall of the right auricle. Its signal spreads over the surface of the heart and causes first the auricles and then the ventricles to contract in proper sequence. Normal frequency is 75 beats per minute. In the average person, five or six quarts of blood are circulated about once every minute.



now made of straight elastomeric tubing, with the pumping action carried out by external compression of the tube by rotating rollers. There are a few modifications of this basic type. In one of these, the Sigmamotor Pump, one or two tubes are compressed by "fingers," but the general pumping principle is the same.

Although the existing heart-lung machines are adequate to oxygenate and deliver blood to the patient in a tolerable fashion during surgery, none of them is ideal, and certainly none gives evidence of being a potential lifetime heart substitute.

DESIGNERS AND DOCTORS

Closer collaboration between the engineering and medical professions is now imperative, says Mitchell Sabanas, the author of this article. He points to the fact that medicine has probably benefited the least from the tremendous advances in all fields of engineering. Miniature mechanisms and components, materials with unusual properties, and many other products which lend themselves to medical applications are merely waiting for doctors and engineers to use them. Accordingly, Mr. Sabanas suggests that it may now be appropriate to set up educational programs in a hybrid specialty to be known, perhaps, as medical engineering. Whatever the answer, the problem deserves wide attention, because combined efforts of the medical and engineering professions in the past have produced spectacular results. As examples, Mr. Sabanas points to recent outstanding developments in the field of heart research.

It has long been recognized that muscles respond to stimulation by electric current. Doctors and engineers recently translated this phenomenon into a lifesaving piece of hardware called the Pacemaker (MACHINE DESIGN, July 9, 1959). The much-publicized device is battery-powered, transistorized, and accomplishes heart stimulation by pulsing electric current through fine leads attached directly to the heart. It has been used in restarting a heart after it had stopped beating during surgery or following a coronary attack. It has also been used as a substitute for the tissue which conducts the heart impulse from the auricles, in cases where this tissue is damaged.

Another similar medical-engineering achievement is the heart booster. This mechanism is created by transplanting part of the heavy muscle which moves the lungs, and wrapping it around the aorta. The nerve is electrically stimulated, causing the muscle to squeeze the aorta rhythmically, thus assisting the weakened heart to pump blood. An exceptionally clever electrical circuit controls stimulation. An arm electrode detects the heart's actual beat, sends an impulse to a transmitter which, in turn, relays the impulse to a receiver implanted in the body. The receiver then sends the signal to the transplanted muscle which contracts the aorta in rhythm with the heart.

These, and other devices, have proved satisfactory over short periods of time, but there is no present equipment available to perform the heart's function on a "lifetime" basis. This, ultimately, is what Mr. Sabanas and his associates are striving for. They face several major problems, including lack of a power source that approaches the power-to-weight ratio of the heart, and lack of materials, compatible with the bodily environment, which can withstand a lifetime of flexing. These are typical medical-engineering problems.

Surveys of Student Recruiting Suggest Improved Practices

NEW YORK—Wooers of engineering graduates-to-be apparently could polish up their techniques. College placement officers and company personnel executives, two groups surveyed by the American Management Association on the subject, agree that recruiting practices could be improved. Placement officers offered these suggestions:

- The recruiter should spend more time discussing a candidate's interests and qualifications, less time on information about his company which could be presented in printed form.
- Literature should include specific job descriptions rather than generalizations and "glamour."
- Duties of a job should be detailed so that a new employee will not feel insulted if he is assigned menial tasks.
- If recruiters are not interested in students with lower than a B average, they should say so.

Placement officers, commenting on the subject of student evaluation by recruiters, said that too much emphasis is placed on personal impressions, and that recruiters tend to hire carbon copies of students who worked out well the previous year, often overlooking good men who vary slightly from the mold.

One-fourth of the 273 companies surveyed thought that their recruiting programs were inadequate. Suggested improvements — better informed and better briefed recruiters, more exact information on jobs available, better literature—closely parallel the college placement group's ideas.

Stress Changes Resistance of Whisker-Sized Semiconductor

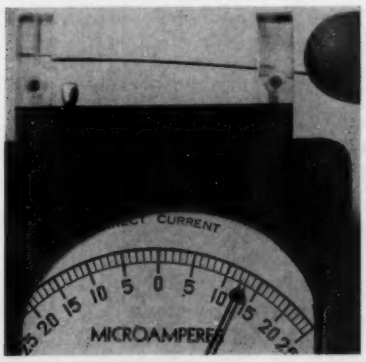
Single-Crystal Element Is Undamaged by Overloads

PASADENA, CALIF. — A new strain-sensing semiconductor element possesses a sensitivity 50 times greater than metallic strain sensors. It's applicable to transducer measurements of pressure, linear and angular acceleration, vibration, displacement, and force.

Developed by Electro-Optical Systems Inc., the element is a whisker-sized semiconductor, 0.001-in. diam x ¼-in. long, that changes resistance when subjected to physical stress. Two whiskers are attached to a cantilever beam so that one is in tension and the other in compression when the beam is deflected. Connected as legs of an electrical bridge, the whiskers produce an unbalanced output signal when strained.

The whiskers boast an ultimate gage factor of 175 compared to less than 5 for wire strain elements. Single-crystal construction of the element endows it with sufficient strength to accommodate overloads that would cause permanent deformation in metallic elements. It can be bent into a complete loop without breakage and still return precisely to its original position.

Whisker strain-sensing elements possess high signal-to-noise ratios due to low impedance and high gage factor. Elements will operate at temperatures to 1000 F.



Two piezoresistive whiskers are bonded to the free end of the cantilever. One is in tension when the other is in compression. They form a resistance bridge that is connected to a battery or other suitable power source. The bridge output is an unbalanced electrical signal that varies with strain.

This revolutionary Carter Rotary Torque Actuator gives engineers a whole NEW field of design opportunities! Up to 370° of rotary fluid power as standard... Safe, powerful torque from air, oil, gas or water power. Zero leakage! Built in cushions! Infinite positioning flexibility! Thousands of applications!

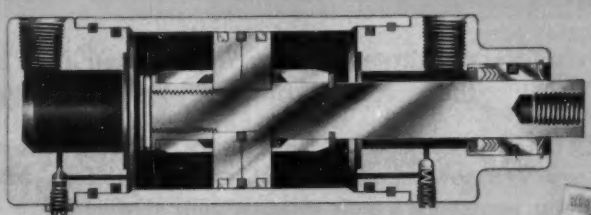
ROTARY

TORQUE ACTUATOR
0-100°
0-190°
0-280°
0-370°
as standard
PNEUMATIC or HYDRAULIC

Patents Pending

Send for 12-page Bulletin with complete engineering data.

CARTER offers unlimited cost-cutting design opportunities through industry's only COMPLETE LINE of LINEAR and ROTARY fluid power actuators!



HYDRAULIC AND PNEUMATIC CYLINDERS

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LINEAR

1. Space saving designs! Light weight!
2. Full 1 to 1 Meehanite cartridge rod bearing.
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4. Spring loaded "V" packing on rod end gland.
5. Key type stainless steel locking ring. Allows 360° rotation of pipe ports.

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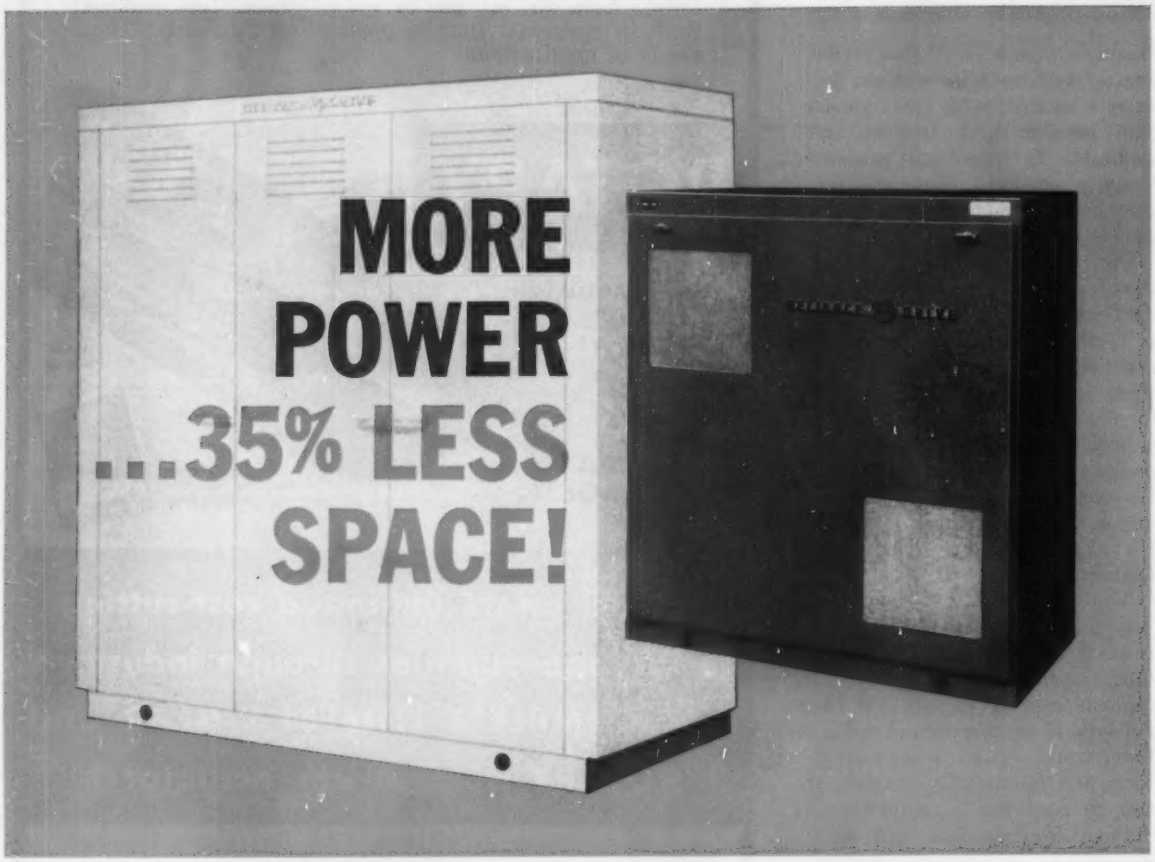
Circle 414 on Page 19

Reliance Super 'T' V★S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1641

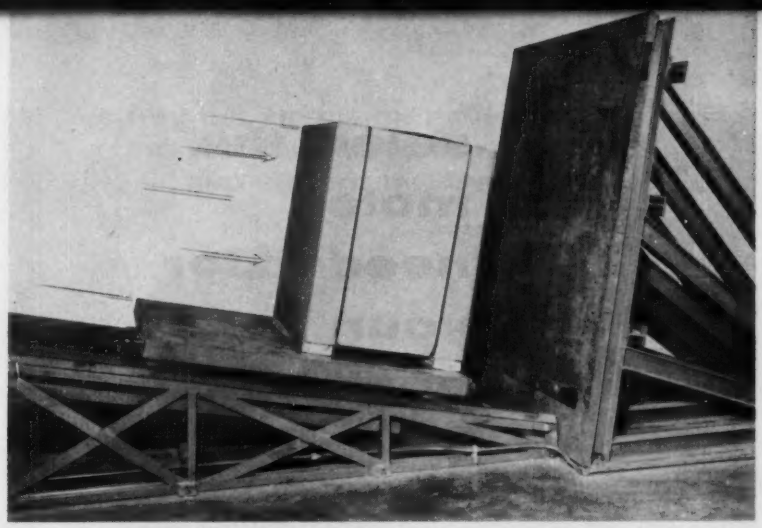
Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 283A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in principal cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

Circle 415 on Page 19



Inclined-ramp impact machine is one of the two torturers of prototypes. Carriage of the 2500-lb machine seats the unit while traveling down the incline. Starting distance up the incline is adjusted to give the desired reading on an impact recorder. High-speed motion pictures, when reviewed in slow motion, reveal bending in structural members and other defects that can be "designed out."

Tip-off to design improvement often comes from unexpected sources. For example, Westinghouse engineers crate air-conditioner prototypes, then manhandle them to see if they will take shipping shocks. The original idea was to improve packaging design, but something bigger grew out of it: Analysis of damage now shows where product design changes are needed. It's a new tool that might be called . . .

Mistreatment Engineering

E. L. POWELL
Assistant to Engineering Manager
and
J. J. COONEY
Superintendent Quality Control
Air Conditioning Div.,
Westinghouse Electric Corp.
Staunton, Va.

HOW MUCH influence should shock and vibration—incurred during shipment of an appliance from plant to customer—have on product design? To answer this question, Westinghouse Air Conditioning Division looked into the work of the National Safe Transit Committee and set up a program based on the Committee's analysis of impacts received by a product during shipment.

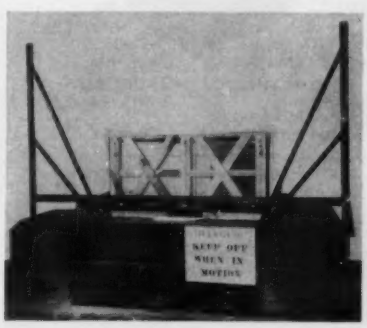
The program has paid dividends. Improved shipping cartons and crates resulted, as might be expected, but faults in the air conditioners themselves also showed up. Analysis of these faults led to:

- Improved quality of products.
- Reduced quantity and cost of materials.
- Discovery of weaknesses that normally wouldn't be detected until field complaints started pouring in.

By itself, the reduction of field-service complaints more than makes up for the cost of transit testing new prototypes. Prototype failures can generally be corrected inexpensively—better tubing supports, stronger fittings, more secure fastening, relocated spot welds, etc. And in some instances, components prove to be over designed — they were stronger than necessary.

But these aren't the only benefits. General design rules can be drawn

(*Please turn to Page 32*)



Second prototype torturer is the vibration table. Frequency of the 500-lb table is adjustable and its drive is equipped with a cam arrangement so that nonsynchronous table tipping and vertical circular motion can both be obtained. Vibration frequency, initially set to simulate the unit in normal operation, is built up to that expected during shipment. Life testing is conducted at an amplitude double that of normal operation.

THE MARK OF QUALITY

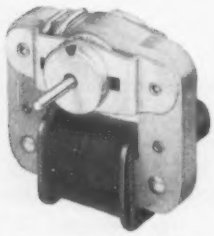
BARBER COLMAN

select the motor needed for your application

Did you know that Barber-Colman Company makes both a-c and d-c motors? On these pages we have tried to tell very briefly a little about each of our motors. Featuring high quality at low cost, Barber-Colman 115 volt a-c (6-220 volt optional) shaded pole motors are excellent for commercial and industrial applications. Barber-Colman d-c precision motors are available in a variety of voltage ranges, styles and specifications to meet airborne and industrial applications. Look at the motors illustrated and then ask us for more literature on the one that interests you most.

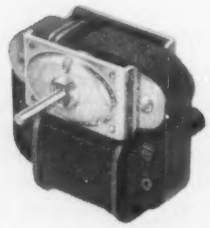
Visit Us At I.R.E. Show Booths 2242-44
New York Coliseum, March 21-24, 1960

A-C SHADED POLE UNIDIRECTIONAL MOTORS FOR COMMERCIAL APPLICATIONS



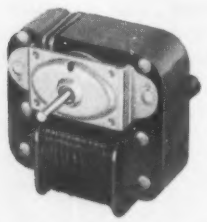
AYAA — DYAA — KYAA

Specifications:
Rated horsepower ...0007 to .0010
Length .....1-1/8" plus shaft
Dimensions.....2-7/32" x 2-1/4"
Remarks .....Exceptionally small and compact
Typical applications — fan blades, blowers, reroll chart drives, phonographs, and gear trains.



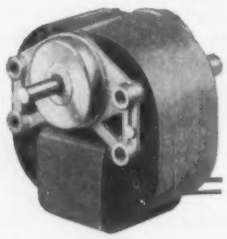
DYAB — KYAB

Specifications:
Rated horsepower ...0017 to .0066
Length ....1-5/8" to 2" plus shaft
Dimensions....2-3/8" x 2-19/32"
Remarks ....High starting torque
Typical applications — slide projector fans, hair dryers and refrigerators, vending machines, office machines, and rotisseries.



DYAF — KYAF — OYAF — CYAF

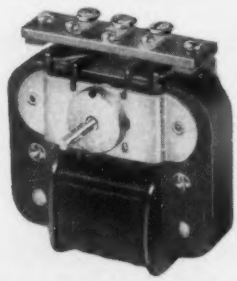
Specifications:
Rated horsepower ....0045 to .032
Length .....1-5/8" to 2-9/16" plus shaft
Dimensions....2-21/32" x 2-3/4"
Remarks ....High running torque
Typical applications — fans for heaters, deodorizers and electronic equipment; blowers and gear trains.



AYAR — BYAR — CYAR — DYAR EYAR

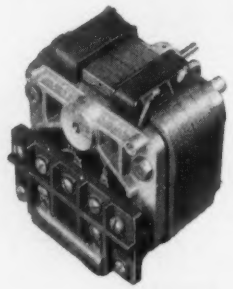
Specifications:
Rated horsepower .....005 to .050
Length .....1-29/32" to 3-11/32" plus shaft
Dimensions.....3-1/8" x 3-1/4"
Remarks .....High start or high power rotors available
Typical applications — pumps, humidifiers, vaporizers, combustion and industrial controls.

A-C SHADED POLE REVERSIBLE MOTORS



AYAG — AYAE — BYAE

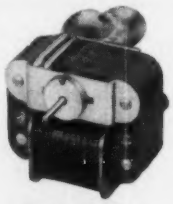
Specifications:
Rated horsepower ....00015 to .006
Length .....1-13/64" to 1-53/64" plus shaft
Dimensions .....3" x 2-7/8"
Remarks .Adaptable to 1 or 2-phase operation and electronic control
Typical applications — servomechanisms, remote switching and positioning devices, and pen drives.



CYAE

Specifications:
Rated horsepower .....0055 to .04
Length .....3-1/8" plus shaft
Dimensions .....3-7/8" x 3-7/8"
Remarks .Adaptable to 1 or 2-phase operation and electronic control
Typical applications—servomechanisms, recording instruments and automatic weighing machines.

A-C SHADED POLE SYNCHRONOUS MOTORS

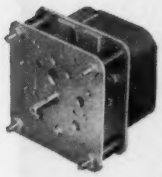


KYAJ — DYAJ

Specifications:
Rated horsepower .....0043 to .0086
Length ..1-3/4" to 2-1/8" plus shaft
Dimensions ...2-11/32" x 2-19/32" or 2-23/64" x 2-19/32"
Remarks ...Develop 30 times power of ordinary clock motors
Typical applications—oscillographs, scoreboard timers, viscometers, facsimile recorders, x ray timers, and microfilm cameras.

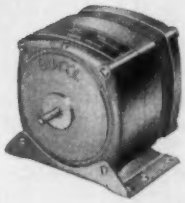
A-C GEARED MOTORS

SYNCHRONOUS UNIDIRECTIONAL
REVERSIBLE



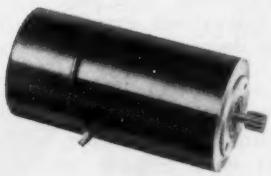
DOUBLE-PLATE

ENCLOSED TYPE



Barber-Colman a-c geared motors provide ratios from 4:1 to 1,333,800:1. Heavy duty gears and output shaft plus long life lubrication add to the reliability of these geared motors.

A-C 400-CYCLE MOTORS



AYLO

Specifications:
Type . . Split-phase capacitor, squirrel cage rotor
Rated horsepower . . . up to 40 mhp intermittent duty
Voltage . . . . . 115 V a-c
Rated speed . . . . 9500 to 11,000 rpm
Length . . . 2.20" excluding shaft and brake
Diameter . . . . . 1.50"
Brake . . . . 400-cycle brake optional

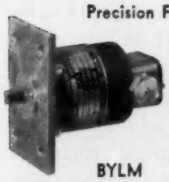
A-C & D-C TACHOMETER GENERATORS

For Commercial Installations

Type AYAE a-c reversible shaded pole motor acts as a low-cost, rugged, accurate, and dependable a-c tachometer or rate generator.

AYAE

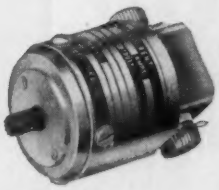
Precision For Military Usage



BYLM and FYLM generators are capable of output voltages up to 40 volts per 1000 rpm, with high linearity and low ripple content. Excellent for servo rate feed back.

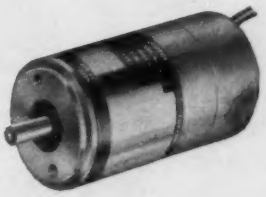
BYLM

6-115V D-C PRECISION PERMANENT MAGNET, REVERSIBLE MOTORS FOR AIRBORNE AND INDUSTRIAL APPLICATIONS



BYLM

Specifications:
Rated horsepower . . . . . up to 0.1 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 7 to 155 watts
Length . . . . . 2.19" to 3.19" excluding shaft
Diameter . . . . . 1.50"

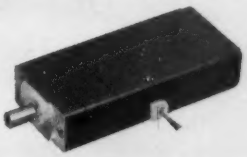


FYLM

Specifications:
Rated horsepower . . . . . up to .055 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 2 to 70 watts
Length . . . . . 1.77" to 2.40" excluding shaft
Diameter . . . . . 1.25"
Features . constant brush pressure; R3 bearings; 3/16" dia. shaft.

DYLM — EYLM

Specifications (EYLM only):
Rated horsepower . . . . . up to .055 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 7 to 155 watts
Length . . . . . 1.83" to 2.45" excluding shaft
Diameter . . . . . 1.38"
DYLM is a split series motor in the same envelope.



GYLM with Matching gearhead

Specifications:
Rated horsepower . . . . . up to .040 intermittent duty
Rated speed . . 2,000 to 24,000 rpm
Power input . . . . . 3 to 60 watts
Length . . . . . 1.97" excluding shaft and gearhead
Diameter . . . . . .75" x 1.63"
Remarks . . . Rectangular gearhead optional, as illustrated.

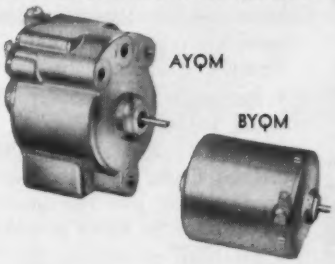
BLOWERS, GEARHEADS, RIGHT-ANGLE DRIVES, FILTERS

Gearheads

Right-Angle Drives, Filters

Barber-Colman d-c motors can be adapted to a variety of uses. Several sizes and styles of blowers and gearheads are available. Right-angle drives and multiple-shaft outputs can also be had for special applications. Radio noise filters furnished if desired.

D-C BATTERY-OPERATED ECONOMY MOTORS



AYQM

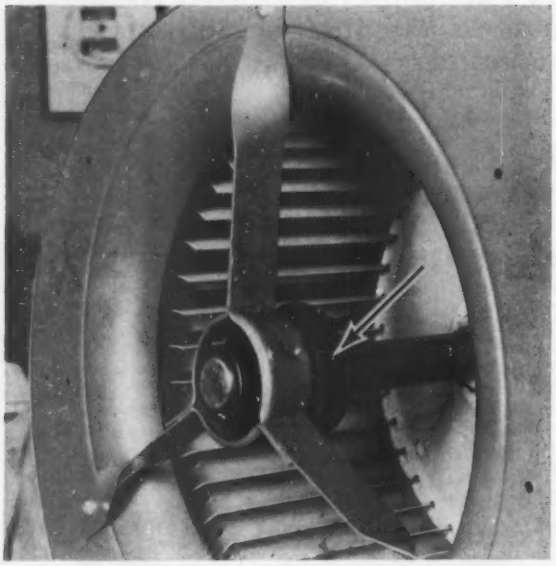
BYQM

Specifications:
Rated horsepower . . up to 0.5 watt continuous
Voltage . . . . . 4.5 to 30 V d-c
Rated speed . . . . 1200 to 6000 rpm (governed)
Power input . . . . . 1 to 5 watts
Length . . . 1.54" to 1.69" excluding shaft
Remarks . . Patented integral governor for battery operation. Reversible.

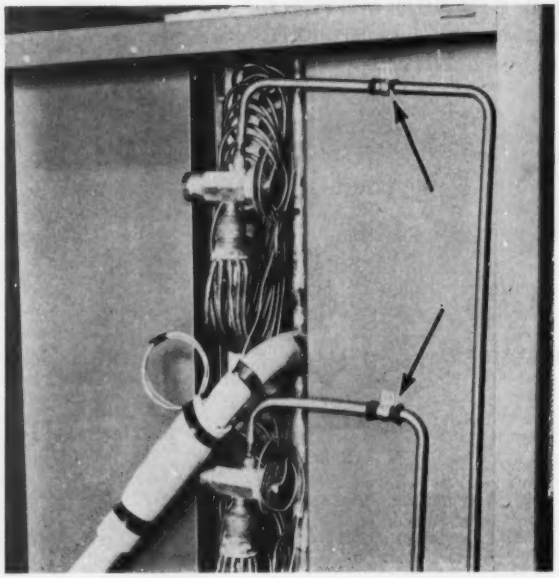
BARBER-COLMAN COMPANY

Dept. C, 1273 Rock Street, Rockford, Illinois

Circle 416 on Page 19



Fan-bearing support failed the vibration test—it was flexible in the plane of the side sheet. The bearing was dislodged from its seat and the fan was damaged beyond repair. The designer corrected the fault by increasing the interference fit and relocating spot welds. Normally, forces parallel to the direction of the fan shaft are negligible, but in transit these forces can be magnified.



Two small tubing lines on one air-conditioner model vibrated excessively during life testing. Life was estimated at approximately three years of normal service. Retaining clips were added to hold each line in place, and no further difficulty was evident on retesting. Since the clips cost about half a cent apiece, mistreatment engineering corrected the weak point in the design at a negligible cost.

(*Continued from Page 29*)

up after analysis of safe-transit requirements. For example, design of sheet-metal housings is now checked against recommendations resulting from the program. Housings do their assigned jobs with reasonable factors of safety, yet can be fabricated at minimum cost.

A logical extension of the Westinghouse safe-transit program was to include accelerated life tests. New products are exposed to test vibrations of normal operating frequency but double the normal amplitude. This points out weak spots in design that would not be apparent for years in the field.

Life tests have shown, for example, that tubes from an expansion-valve distributor to an evaporator were rubbing against each other on one type of air conditioner. Tubing probably would have failed in three to five years. By changing the design so that no tube could contact another, the designer extended machine life at little cost.

The safe-transit program has also been a boon to quality control. In one case, a production unit under test failed because copper tubing had not been properly annealed. While this was being corrrected, the designer added a fastening clip to hold the tubing—even though tests on the prototype did not show such a clip was necessary. It is doubtful if normal quality control methods would have caught this fault. Now, one of the first three units of every new model is tested; if manufacturing or tooling mistakes are present, they are generally detected by failure of the unit.

Solution Found for Government's Employment Problem: Money

NSPE Offers Proposals for Hiring, Keeping Engineers and Scientists

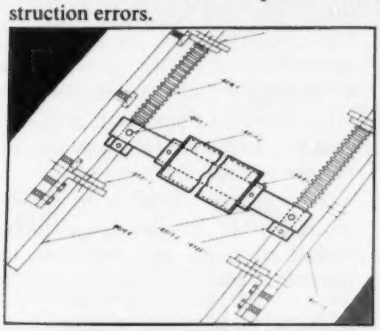
WASHINGTON—The National Society of Professional Engineers has submitted a five-point plan to the House Committee on Post Office and Civil Service for improving the government's chances in competition for engineers and scientists. NSPE recommends revising the Federal Classification Act to:

- Authorize agency heads, if practical, to set starting rates for engineers and scientists at a level comparable to prevailing rates in industry and other fields.
- Recognize an unusually high demand for certain kinds of talent, particularly in new and highly specialized fields, and establish salary levels which put the government in the race for these people.
- Establish procedures for "quick, efficient, and effective" salary adjustments as nongovernmental pay rates change.
- Reward outstanding ability, merit, job performance, and responsibility through adequate salary adjustments.
- Eliminate the artificial distinction between "super grades" (GS-16, 17, and 18) and the other 15 grades of the General Schedule and remove limits on the number of such positions.

NSPE emphasized the need for flexibility in the federal salary system to aid in the solution of the government's "recurring problems with respect to engineering and scientific personnel."

Ever Want Prints Emphasizing Parts of a Drawing?

Engineers, architects and many other types of technical people often want prints that separate key parts of a drawing from the rest of it, and some weird and costly techniques have been used. This is understandable because the cost of *not* getting good separation or emphasis can also be shocking. Take the case of a large West Coast engineering organization constantly involved in plant construction. They used sepia prints of floor plans to lay out the electrical work. But the lack of contrast between the plumbing shown in the sepias and the electrical layouts added required hours of careful checking and frequent revisions, even caused some expensive construction errors.



Diazo print from special-blue image intermediate produces a sharp contrast between the parts to be emphasized and those to be subdued.

That's all ancient history now! Two of Dietzgen's numerous modern drafting-printmaking aids have turned this tough old chore into a picnic. They are new drafting media (one a polyester film and the other a vellum) diazo sensitized to produce a special blue image. The reproduction of your basic drawing on either of these media is bold and clear so drafting additions can be made without confusion or error. But when you make prints from the completed intermediate, the basic part in the special blue prints faintly (clearly visible but subdued) . . . while the added drafting, even in pencil, prints strong and bold. The results are perfect, easily and quickly obtained, delightfully inexpensive.

SOLVED: A COSTLY PROBLEM OF COMBINING DRAWINGS AND GRAPHS

Drafting time costing as much as $40 was used to draw a single grid . . . and draftsmen resented the tedious assignment.

A large manufacturer of automotive parts decided to plot their graphs directly on the drawings in order to end the nuisance of their being separated in handling, filing, plant interchange, etc. But this created many new problems. Tracing or drawing the grids in position proved costly, as much as $40 each in drafting time. They were rarely accurate and never uniform in character. The lines often smudged and usually reproduced poorly. The work created a morale problem because draftsmen resented the tedious assignment.

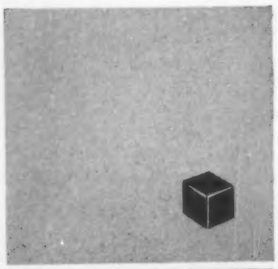
One of Dietzgen's modern drafting-printmaking aids furnished a perfect answer! It is a light-weight drafting film which is adhesive-backed and furnished printed with a stock grid. It is simply mounted in place and the grids are sharp, clean, clear and uniform, so much more accurate that fewer plotting points are needed to develop the graphs. Reproductions were so noticeably better as prints moved through other departments and associated plants that the change was investigated and quickly adopted. Much needed drafting time and capacity is saved and the reduction in costs amounts to many thousands of dollars a year.

Drafting-Printmaking Handbook reports new techniques for solving engineering and production problems

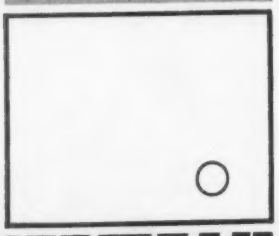
This new 36 page handbook describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-C-160 Eugene Dietzgen Co., Chicago 14, Illinois.

DIETZGEN

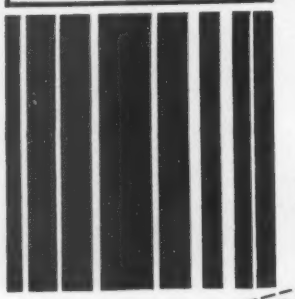
EVERYTHING FOR DRAFTING SURVEYING & PRINTMAKING



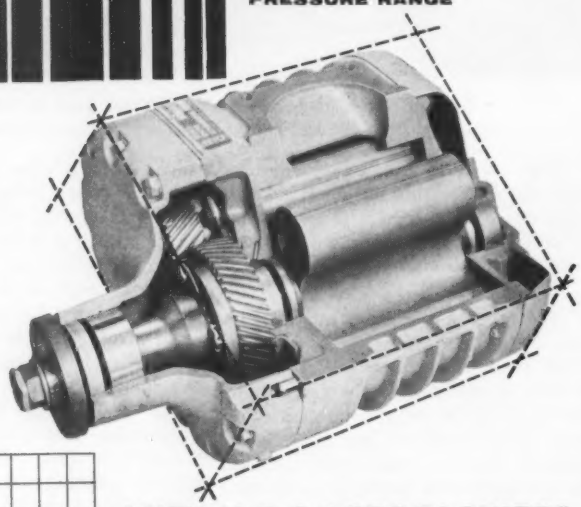
SMALLEST CUBE DIMENSIONS

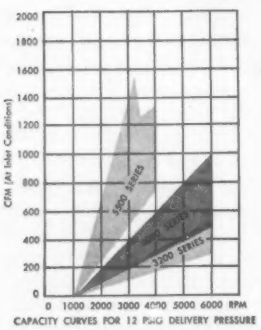


LIGHTEST WEIGHT



WIDEST PRESSURE RANGE





WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

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Defense Department Sets Up Plastics Data Center

Picatinny Will Be Arsenal Of Technical Information

INSTANT RESEARCH results, saving money, effort, and—most important—time, will be available to the plastics industry when a new Department of Defense facility is in full operation. To provide information usually acquired only after much study and experimentation, a Plastics Technical Evaluation Center is being established at Picatinny Arsenal, Dover, N. J. The following functions are proposed for the Center:

- To collect, evaluate, store, and disseminate technical information on current development, engineering, and application work in plastics and reinforced plastics.
- To provide technical assistance and consulting services to military contractors and suppliers on problems involving the use of plastic materials.
- To prepare and issue state-of-the-art reports on important and advanced technological aspects of plastics engineering.
- To stimulate advances in standardization of processes, products, testing methods, and materials in the field of plastics.

Research: Demand and Supply

Scientific achievement, once not much more than a "prestige" activity and a possible source of new ideas for industry, is now recognized as essential to national survival. Even in the pre-Sputnik era, scientific research was recognized as a valid and essential (if costly) function of the national government; now the general public has adopted the attitude: Hang the expense; get on with it.

Since research is limited more by time and the availability of technically qualified people than by money, information produced by research should be used to the greatest possible advantage. Getting research data into the hands of engineers where it can be applied can be best accomplished through technical evaluation centers, which

Circle 438 on Page 19

NEW *EMRALON*® TFE COATINGS SOLVE HEAT SENSITIVE APPLICATIONS

Acheson's resin-bonded tetrafluoroethylene (TFE) surface coatings are finding ready acceptance among design engineers. Where previous limitations of pure TFE prevented its application on heat sensitive substrates, because of its 700° F. sintering temperature, 'EMRALON' coatings are being successfully used on rubber, light metals, woods, and plastic. One such impressive case history is outlined here.

'EMRALON' coating is shown being spray-applied on woven belting with conventional equipment.

OVER $15,000.00 ANNUAL SAVINGS PROJECTED BY PROMINENT TIRE MANUFACTURER

Dunlop Tire and Rubber Corporation, Buffalo, N. Y., estimates this considerable savings in down-time costs alone on the basis of nearly nine months production use of an 'EMRALON'-coated belt conveyor. The particular belt involved is thirty feet long. Its importance in this company's tire production is emphasized by the fact that it is located at the point of a previous bottleneck. Rubber strips, conveyed from a series of masticating mills to an extruding press, formerly became stuck to the belting of this short-run conveyor immediately above the final masticator. The reason: the temperature of the rubber is elevated — through friction of the masticating process — to between 150° F. and 300° F. at this point. Belts had to be replaced anywhere from once every several hours to every six weeks. It was not unusual to have two or three stoppages every shift. The result: with the supply of rubber temporarily cut off, the entire department shut down. Costs ran $5.00 a minute, and with these work stoppages averaging 20 minutes each, the accumulated expense became prohibitive. Since April, 1959, the new belt has been in constant operation at this critical point in the masticating line.

To date it has not been removed from the mill . . . ample proof of the extraordinary non-stick, adhesion and flexing qualities of its 'EMRALON' coating!

The woven conveyor belt is a product of Globe Woven Belting Company, Buffalo, N.Y. Application of Acheson's 'EMRALON' to their belting was the outcome of a continuing research program headed by Globe Research Manager, Fred Kohlhagen. It is applied by standard commercial spray equipment to a film thickness of 0.7 mils and then oven-cured at a temperature of 300° F.

According to Mr. Kohlhagen, "This example will be only one of many success stories told about this coating. 'EMRALON'-coated belting can be used anywhere a slick, non-corrosive belting is needed. Those in the baking, canning, food processing, food packaging, and rubber fields should find immediate use for it." We might add that there are many other industries finding it advantageous to use 'EMRALON' . . . yours quite possibly is one of them. Why not write today for further information?

'EMRALON' — coated conveyor belt carrying hot rubber through masticating mill.

'dag' is a trademark registered in the U. S. Patent office by Acheson Industries, Inc.

'EMRALON' ADVANTAGES PROVED IN MANY LIGHT-LOAD USES

The growing list of production applications for the new Acheson 'EMRALON' surface coatings, is convincing proof of their versatility. That film pack, office machine, and lock mechanisms; rubber molds and oil seals; bakery dough handling equipment and countless other light load, solid-film lubrication problems have successfully been answered, is now a matter of record.

With 'EMRALON' 310* — colloidal TFE in a phenolic resin solution — a one-hour cure at 300° F. is all that is necessary. And, for substrates even more sensitive to heat, 'EMRALON' 320** colloidal TFE in a thermo-plastic resin carrier — is available. Both provide excellent adhesion, low coefficient of friction, flexibility, toughness, and corrosion resistance. Applied by conventional paint spray equipment, they allow easy production line conversion to 'EMRALON' solid-film lubricants.

'EMRALON' coatings represent the latest in a long line of widely accepted Acheson products, one of which may offer a ready-made answer to your particular lubrication problem. We welcome the opportunity to be of service. Send for your copy of our Products List which outlines the full line of Acheson Dispersions. Address Dept. MD-30.

*'EMRALON' 310 is manufactured under exclusive license from E. I. duPont deNemours & Company (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.

**'EMRALON' 320 — patent applied for.

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Circle 418 on Page 19

Advantages of Technical Evaluation Centers

They permit engineers to use highly advanced technology.

They save time for both engineers and applied scientists.

They provide a bridge between great collections of data and the users, thereby making the data collections more valuable. In effect, they give technical support to the library function.

They prevent ill-advised excursions of unqualified people into unfamiliar technology.

They eliminate unnecessary duplication in tests, exploratory engineering, and reconnaissances into unfamiliar fields.

They afford a quick source of reliable, if not completely authoritative, technical information.

They reduce the number of unmade and awkward, if small, technical decisions to be made by each new entrant into a field.

They develop an accessible and growing accumulation of "best data" in important technical areas.

They provide an additional means for informal dissemination of unwritten technical data on a where-needed and when-needed basis.

They fill the gap between research findings, and critical tables and industrial standards.

offer the same information as a library, but also provide a judgment factor. This is an "indispensible ingredient," according to John R. Townsend, Special Assistant to the Director of Defense Research and Engineering.

Mr. Townsend says, "For engineers, it is of less importance that all information be exhaustively accumulated on any given subject than that a sound body of *useful* technological information — engineering data, process standards, quality and performance expectations—be compiled and placed in the hands of those who need this information, in a form which they can use."

Such thoughts as these led to establishment of a Titanium Metallurgical Laboratory in 1954 to supply information on the then-new metal. This laboratory was set up at Battelle Memorial Institute to serve persons and companies "whose needs for technical data on titanium were directly or indirectly connected with defense."

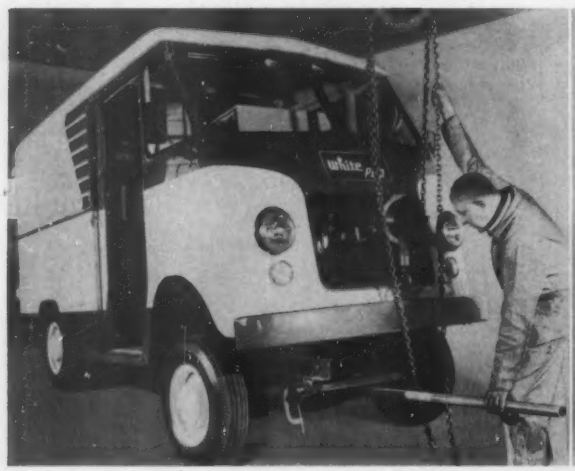
The laboratory's duties included collecting all possible data on titanium and similar metals, doing limited research, supplying technical information, and issuing papers—sometimes speculative—as a means of inspiring outside development.

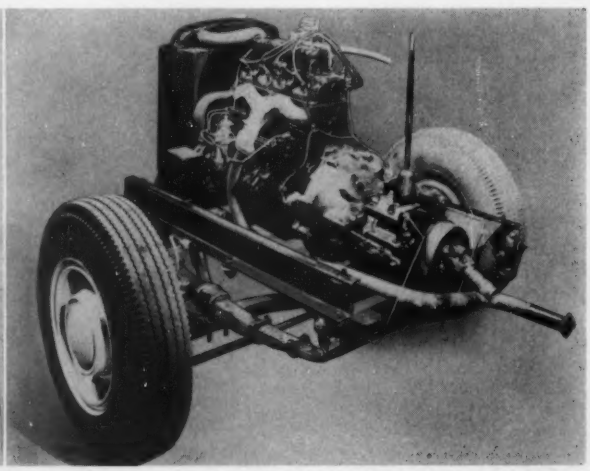
Success of the titanium venture led to expansion of activities at Battelle into the Defense Metals Information Center, which is concerned with high-strength steels, beryllium, and refractory metals for special military uses.

Plastics Are Picked

Setting up an evaluation center for plastics information was a logical next step, since plastics are finding wide application in missiles and other military gear. Because the ultimate standards for reliability demanded by military equipment seemed beyond the reach of the plastics industry, and because of the potential of plastics, the Department of Defense believed that government action was warranted. Accordingly, the Plastics Technical Evaluation Center is now being established at Picatinny along the lines of the Battelle titanium center. The Defense Department emphasizes that the Center is still in the formative stage but looks forward to a "valuable and constructive activity" when it opens.

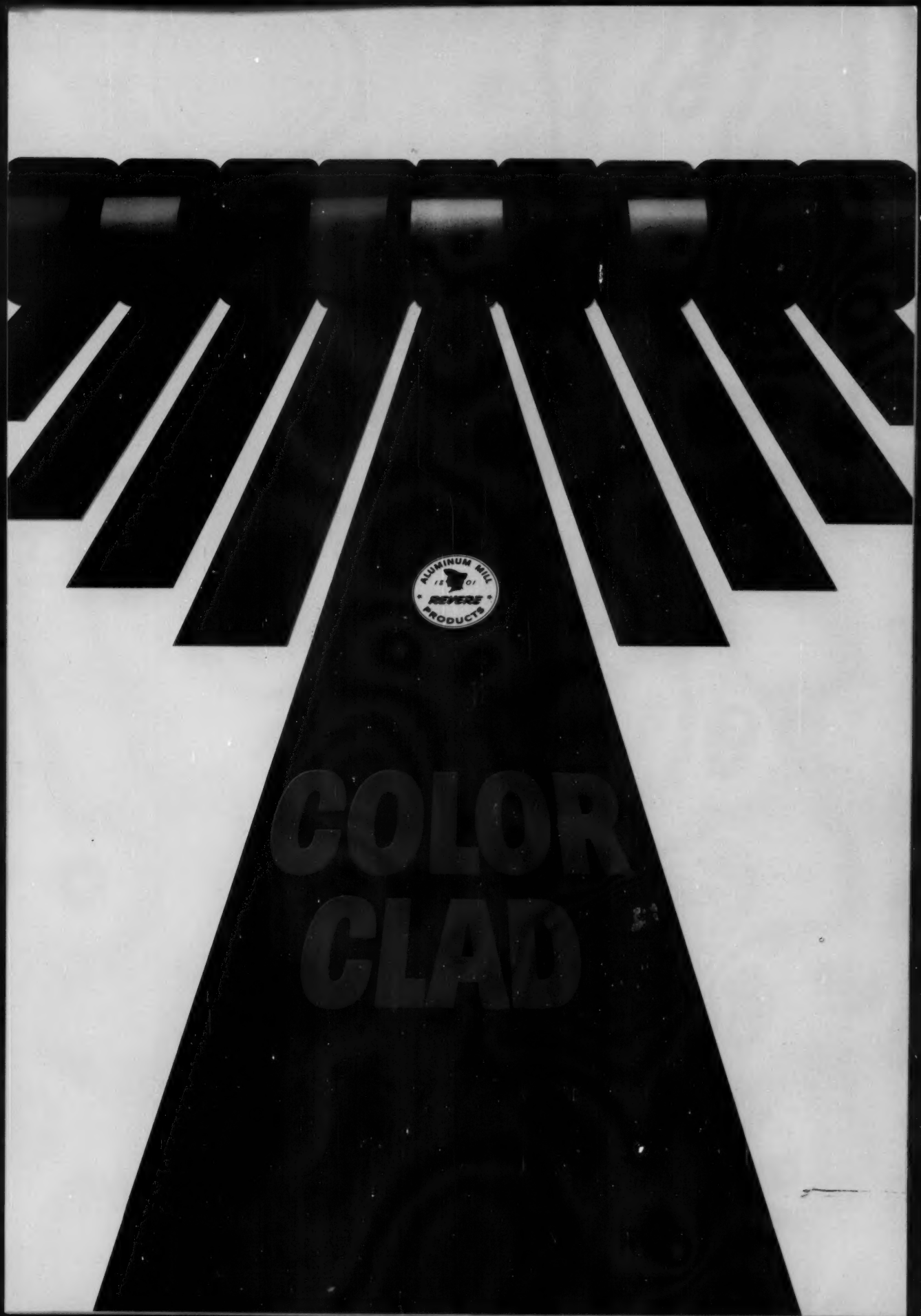
Power Dolly for a Delivery Truck





First entry into the delivery truck field by White Motor Co., Cleveland, is the company's PDQ—for Pickup and Deliver Quickly—series. The truck boasts many progressive features, including a removable power dolly (right). The entire front-end power assembly can be removed as a unit by disconnecting the dolly from the frame, making a few component disconnections, and pulling out the unit (left). A spare dolly can be connected and the truck put back into service—one man can remove and replace the unit in less than three hours. An adapted version of the Willys Jeep F-head, four-cylinder engine is the standard powerplant, and engines and heavy-duty transmissions are matched, assembled, and balanced together before they are mounted on the dollies.

Circle 419 on Page 19→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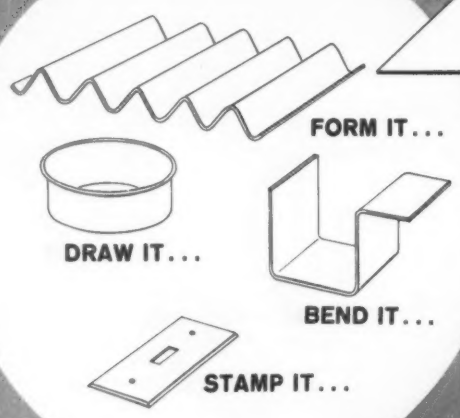

The built-in quality of Revere Color Clad Aluminum Sheet prevents it from cracking, chipping or peeling. The finish is formulated to meet your specific production needs.

. . .

WHEREVER BEAUTY AND UTILITY ARE REQUIRED, SPECIFY REVERE COLOR CLAD ALUMINUM SHEET... FOR COLORS THAT LAST SEE REVERE FIRST!

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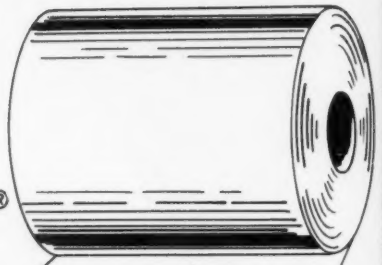

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Does away with all your finishing costs and problems . . . gives your product a better, more lasting finish plus added sales appeal

Revere Color Clad Aluminum Sheet comes to you in colored coils ready for drawing, bending, forming or stamping. The most modern chemical treating, coating, and baking facilities, backed by rigid quality controls, assure you of consistent color and finish quality.

Now you can produce a better product to sell to your customers, and at the same time eliminate your own costly finishing operations. Recover valuable factory space—turn paint inventories into cash—reduce handling—(and save on your fire insurance rates too!).

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Revere Color Clad Aluminum Sheet comes in vinyls, alkyds, acrylics ("Lucite*") epoxies, organisols, plastisols, painted one side or two, same color both sides or different each side—all available for *your* product, to fit your manufacturing requirements. We will meet your specifications—or recommend the finish best suited for your job.

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Full, deep rich tones... light pastels... brilliant metallics... striking flamboyants.. simulated textures (linens and leather). Rich, wood grains in a variety of tones . . . three dimensional embossed plastisols . . all firmly bonded to Revere aluminum so you can form, draw, bend or stamp without cracking, chipping, scuffing or marring. Remember—Revalum won't rust at exposed edges and is light weight for easy handling—now supplied from ¾" to 42", .006 to .050 thick, in most alloys. When you specify Revalum you buy years of experience in the production of Color Clad Aluminum Sheet. For colors that last see Revere first.

*Du Pont's registered trade mark for its acrylic lacquers.

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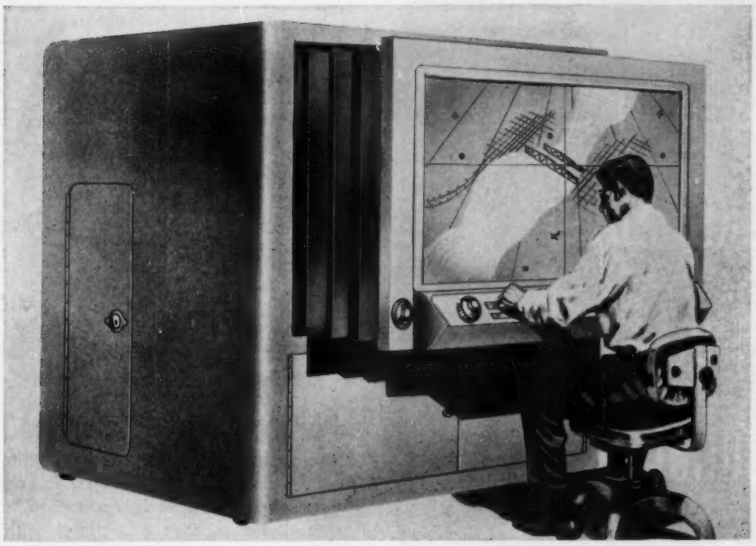
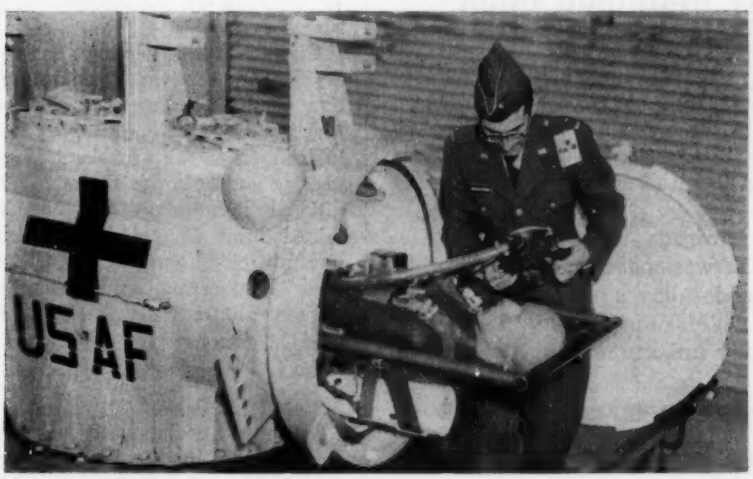


Locator Selects Target Map

Target Map Coordinate Locator, a device being developed for the Army by Fairchild Camera and Instrument Corp., needs only 15 seconds to select one map from a file of over 11,000. It consists of a multideck storage drum holding map transparencies, a movable microfilm pick-up assembly, and a projection-display assembly. The operator dials a number, and the device locates the proper film and carries it to the projector unit for viewing. A crosshair system for target location positions the horizontal and vertical crosshairs on the screen to an accuracy of about 40 ft at a map scale of 1:25,000.



Water Cushions Passenger in Space Capsule

Skin-diving spacedummy suffered no ill effects from a 40-g stop after a 4000-ft ride at 615 mph. A 134-lb anthropomorphic dummy made this trip completely submerged in water in a one-ton steel capsule at the Air Force's Missile Development Center, Holloman AFB, New Mexico. Object of the test was to determine whether a water-cushioned impact will help men withstand high acceleration and deceleration. The dummy was strapped in to take the deceleration feet first. Studies are expected to reveal if and how the g load builds up pressure at the front of the capsule area and how the load shifts on impact. This information is important in determining how much of the load is absorbed by the surrounding medium instead of the passenger. Telemetered test data showed that both the capsule, made by the Norair Div. of Northrop Corp., Hawthorne, Calif., and the sled withstood all programmed stresses.

←Circle 419 on Page 19

Here's a complete ½" In-Line Valve with a 7.5 C_v! Springless (pneumatic or hydraulic), spring-to-open or spring-to-close operation. The operating method can be changed easily in the field without extra parts.

Write or call today for complete details on this extraordinarily compact In-Line Valve for on-off or control applications.

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Circle 420 on Page 19

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Check it now. For complete information, prices and delivery of ISOLOY or other spring materials and a copy of the new "Spring Materials Digest," write: *Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N.J.*

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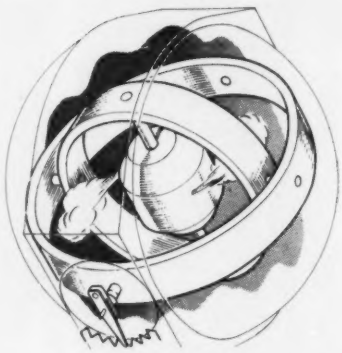


Pyrotechnic Gyroscope

Hot gases from an electrically ignited solid-propellant charge spin a new gyro rotor at speeds up to 36,000 rpm. Rotor reaches top speed within 0.1 sec after charge ignition and provides effective performance for longer than one minute. Drift rate during the first minute is 3½ degrees or less. The device will be made by Giannini Controls Corp., Pasadena, Calif.

Meetings and Shows

March 7—

Cleveland Engineering Society. Seventeenth Annual Machine Design Conference, sponsored by the Machine Design Div. of the society, to be held at the Cleveland Engineering and Scientific Center. Additional information can be obtained from Donald H. Cornish, Executive Director of CES, Cleveland Engineering and Scientific Center, 3100 Chester Ave., Cleveland 14, Ohio.

March 14-18—

National Association of Corrosion Engineers. Annual Meeting to be held in Memorial Auditorium, Dallas. Additional information is available from NACE headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 15-17—

Society of Automotive Engineers Inc. National Automobile Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Circle 421 on Page 19

March 21-24—

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 22-24—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Statler Hilton Hotel, Cleveland. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

March 23-25—

Pressed Metal Institute. Spring Technical Meeting to be held at the Pick-Carter Hotel, Cleveland. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 27-31—

Scientific Apparatus Makers Association. Annual Meeting to be held at Boca Raton Hotel & Club, Boca Raton, Fla. Additional information is available from SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

March 29—

Material Handling Institute Inc. Spring Meeting to be held at the Pittsburgh-Hilton Hotel, Pittsburgh. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

March 29-31—

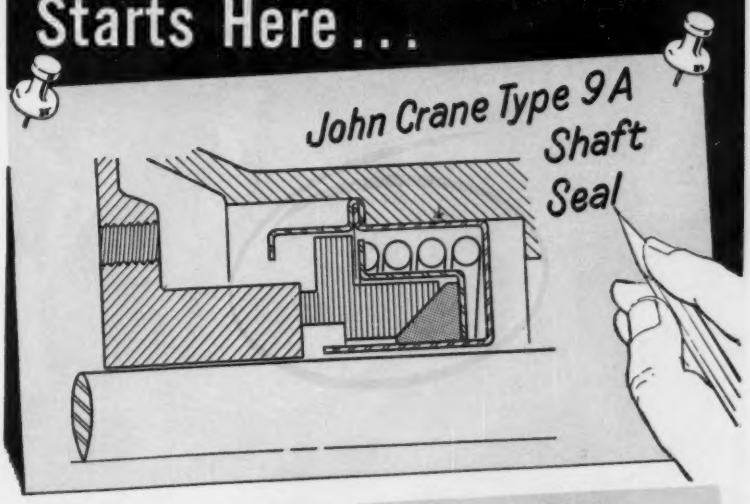
22nd Annual American Power Conference, sponsored by Illinois Institute of Technology in co-operation with a total of 23 technical societies and educational institutions, to be held at the Hotel Sherman, Chicago. Further information is available from conference director R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

April 3-6—

National Screw Machine Products Association. Annual Meeting to be held at the Ambassador Hotel, Los Angeles. Further information

(*Please turn to Page 44*)

Sealing Corrosive Liquids Starts Here...

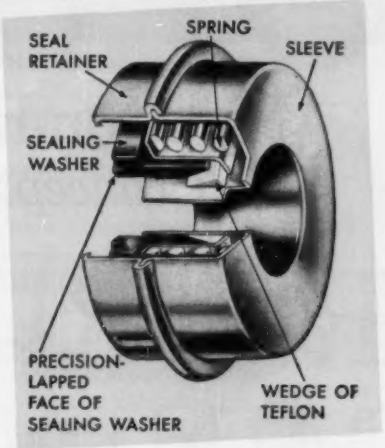


This cartridge-type shaft seal designed for the production line is engineered for:

(1) positive sealing of many industrial chemicals and solvents (note the Teflon* sealing wedge);

(2) leakproof handling of inflammables and toxics;

(3) operation over a wide temperature range from −120° to +500°F., pressures to 150 psi.



It offers the Original Equipment Manufacturers these important advantages:

(1) low unit cost through mass production;

(2) fast, one-piece installation through cartridge construction;

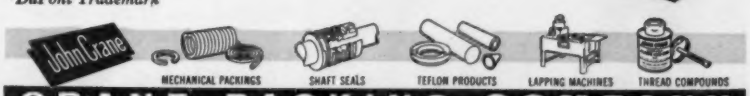
(3) equal efficiency on both low or high speed applications, because seal does not rotate with shaft.

The 9A Shaft Seal can be of stainless steel, monel, brass or other materials adapted to stamping and forming—depending on the service requirement.

Get full details. Request Bulletin S-205-3 from Crane Packing Co., 6425 Oakton Street, Morton Grove, Illinois *(Chicago Suburb).*

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

**DuPont Trademark*



CRANE PACKING COMPANY

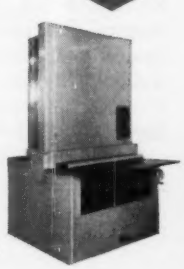
OFFICES IN ALL PRINCIPAL CITIES

Paragon-Revolute *introduces a great new concept in reduced size reproduction . . .*

RETRIEVABLE MINIATURIZATION

The Paragon-Revolute Continuous Reducing Printer is the heart of Retrievable Miniaturization. Really a giant movie camera, it takes pictures of drawings while they move through the machine at speeds variable from 3 fpm. to 30 fpm. It takes drawings up to 42″ wide, offers reductions of 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8 size. If desired, one of two ratios supplied may be 1:1 for originals up to a maximum of 21″ wide by any length. Camera feeds the same as blueprint and whiteprint machines.

A.



B.

Lockheed engineers and Paragon-Revolute representatives compare half-size print with full-size drawing at Lockheed Aircraft Corporation, Missiles and Space Division, Sunnyvale, California. Lockheed officials report that Retrievable Miniaturization has given them the economies and advantages possible from reduced print size without sacrifice of valuable information on engineering drawings.

Andrew T. Johnson, (right) and Robert Johnson, owners of their own reproduction and blueprinting service firm in Boston, were the first to install Retrievable Miniaturization as a commercial service. They state: "Retrievable Miniaturization makes real sense to us —and to an increasing number of our customers. Incidentally, our Revolute Processor is doing a fine job in processing direct positive papers.

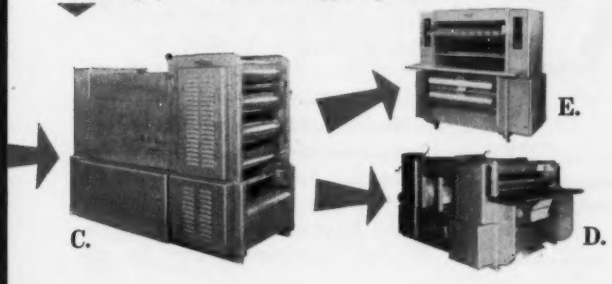
THE IDEA. Retrievable Miniaturization is a new ingenious method for reducing the size of prints yet keeping them large enough to be completely readable and usable. Developed by Paragon-Revolute, this method is acknowledged as one of the significant advancements in reproduction.

HOW IT WORKS. In Paragon-Revolute's unique Continuous Reducing Printer and Processor, reduced-size transparencies are made directly from original drawings for immediate reproduction in blueprint or diazoprint equipment. Reductions can be made as positives or negatives on paper or film. The Printer takes drawings up to 42″ wide by any length at speeds up to 30 fpm.

THE ADVANTAGES. Retrievable Miniaturization fits in with existing facilities, calls for no drastic changes in present drafting standards or print-making systems. It enables savings in materials up to 300% . . . increases capacity of blueprint or diazotype equipment up to 4 times . . . slashes print handling time, filing space, and mailing costs. Most importantly, it provides readable, usable reduced-size prints without the problems and high cost of blowback systems.

You owe it to yourself and your company to investigate the advantages and savings offered by this great new concept in reproduction by mailing the coupon below.

Reduced-size prints are simple and fast to make. A. Original drawings are fed into B. Revolute Continuous Reducing Printer where they are photographed and reduced on paper or film transparencies. C. Revolute Continuous Processor develops, fixes, washes, and dries transparencies for immediate reproduction in D. Blueprint equipment or E. Diazotype reproduction machines.



PARAGON REVOLUTE DIVISION OF CHARLES BRUNING CO., INC. BRUNING

77 South Avenue • Rochester 4, New York

Paragon-Revolute Advertising Department, Dept. 3-W
1800 Central Rd. Mt. Prospect, Illinois

☐ Please send me more information about Retrievable Miniaturization.

☐ Please arrange for one of your representatives to contact me about a demonstration.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Circle 423 on Page 19

UNIFORM TUBING

ALLOYS

ALUMINUM

1100, 3003, High Purity, 2024, 5052, 6061, 6951 and the New High Strength Alloy UT-58.

COPPER

OFHC Copper, Phosphor Copper, 70-30 Brass, Yellow Brass, Red Brass, 18% Nickel Silver, "A" Phosphor Bronze, #25 Beryllium Copper, 30% Cupro Nickel.

NICKEL

"A" Nickel, Monel and Inconel.

STAINLESS STEEL

304, 310, 316, 321, 347, 410.

GLASS-TO-METAL SEALING

#52 Nickel-Iron and "Rodar".

PRECIOUS METALS

Gold and Silver Alloys.

SIZES: O.D. from .005" to .625". Wall Thicknesses down to .001". Tolerances commercial or precision down to ± .00025", on smaller sizes.

•

See Our Exhibit
Booth 4047
I.R.E. Show

UNIFORM TUBES, INC. COLLEGEVILLE 2, PA.
HUxley 9-7276 TWX-CGVL 1044

Circle 424 on Page 19

(*Continued from Page 41*)

can be obtained from association headquarters, 2860 E. 130th St., Cleveland 20, Ohio.

April 3-8—

Nuclear Congress to be held in the New York Coliseum, consists of the 6th Nuclear Engineering and Science Conference, the 8th NICB Atomic Energy in Industry Conference, and the 6th International Atomic Exposition. Congress is sponsored by 28 engineering, scientific, management, and technical organizations. Further information is available from 1960 Nuclear Congress, 33 W. 39th St., New York 18, N. Y.

April 5-8—

Society of Automotive Engineers Inc. National Aeronautic Meeting (including production forum and engineering display) to be held at the Hotel Commodore, New York. Further information can be obtained from the society, 485 Lexington Ave., New York 17, N. Y.

April 7-8—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

"Well, if you go around *looking* for them you're bound to find mistakes."

April 11-13—

Fourth Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and *Automation* magazine. Further information can be obtained from K. E. Glancy, Div. of Adult Education, Purdue University.

April 12-13—

Institute of Radio Engineers. 14th Annual Spring Technical Meeting to be held in conjunction with the American Rocket Society at the Hotel Alms, Cincinnati, Ohio. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

April 18-19—

Third Annual Conference on Automatic Techniques to be held at the Sheraton-Cleveland Hotel, Cleveland. Additional information is available from conference publicity chairman, Room 530, 1213 W. Third St., Cleveland 13, Ohio.

April 19-21—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the Netherland-Hilton Hotel, Cincinnati. Additional information is available from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

April 21-28—

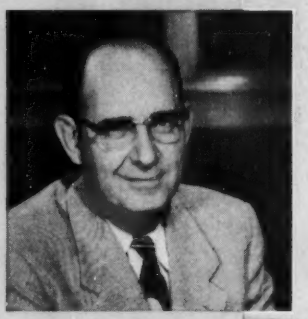
American Society of Tool and Manufacturing Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 25-29—

American Welding Society. 41st Annual Convention and Welding Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS, 33 W. 39th St., New York 18, N. Y.

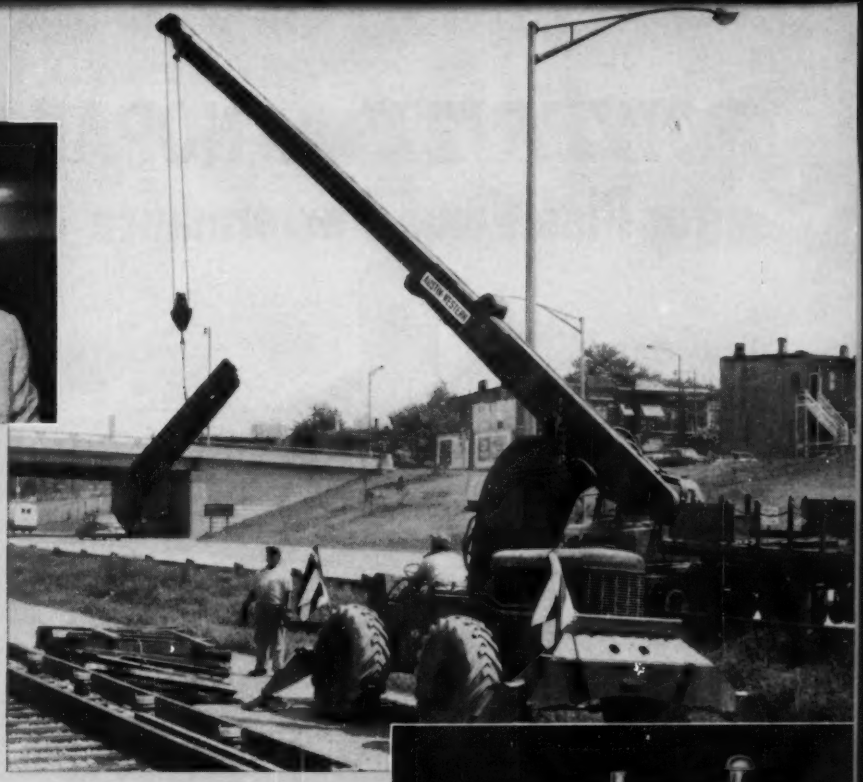
April 27-28—

National Conference on Space-Age Materials to be held at the Sheraton-Gibson Hotel, Cincinnati. Sponsor is the Cincinnati Chapter of the American Society for Metals. Further information can be ob-



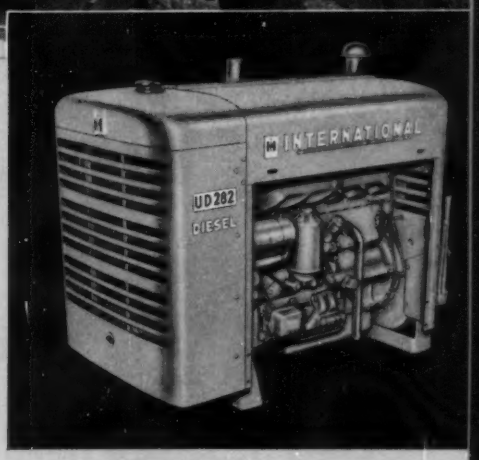
H. P. Lockhart, Assistant Gen. Manager, Sales, Austin-Western, Construction Equipment Division, Baldwin-Lima-Hamilton, Aurora, Ill.

"On-the-job reports prove that IH power is an excellent choice for our hydraulic crane."



Customer's job records show

INTERNATIONAL® Power ideal for AUSTIN-WESTERN Crane



International UD-282 diesel shown here is interchangeable dimensionally with UB-264 gasoline engine.

For their heavy-duty hydraulic crane Austin-Western engineers specified a rugged industrial-type engine, in the 80-90 horsepower class, that would provide dependable power for the boom hoist, yet would operate smoothly and economically at road travel speeds. International UD-282 and UB-264 engines exactly met these requirements and were dimensionally interchangeable. And they gave the customer a choice of either gasoline or diesel fuel. Reports from users show that Austin-Western cranes equipped with International engines are doing outstanding jobs.

When designing your products it will pay you to check International's line-up of diesel and carbureted engines. You will find the rugged carbureted models and instant-start diesels are interchangeable in power and dimensions. And IH power flexibility provides efficient operation through wide variations in load and speed.

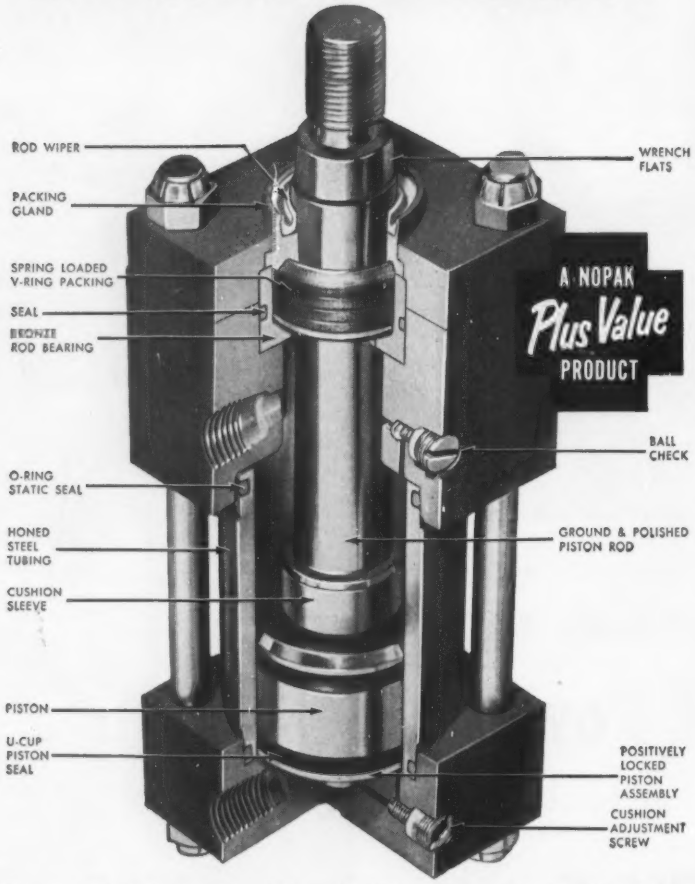
Investigate the many advantages available to you by powering your products with International. You have a choice of 32 engines from 16.8 to 385 max. hp, a size to fit any power requirement. For detailed information call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL® ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE

Circle 425 on Page 19

POWERIZE with NOPAK
for Plus Value Performance



Class 3, Square Head Hydraulic Cylinders

Pressures 3,000 P.S.I. operating, 5,000 P.S.I. proof

Check these Class 3 Plus Values...

- Interchangeable with other well-known square head, hydraulic cylinders
- NOPAK Class 3 Cylinders comply with J.I.C. standards
- Positively locked, one-piece concentric piston
- Piston Construction...
  Self-compensating U-cup *(standard)*
  Multiple seal piston ring *(optional)*
- Expansion Joint Type Tube Seal †...
  Cannot extrude at excessive shock pressures
  Provides bleeder by-pass location at highest internal point
  † a NOPAK *first* since 1948
- Steel Construction for Strength and Durability...
  Heavy Honed Steel tube, Steel heads, High Tensile Steel piston rod and tie rods
- Multiple V-Ring Rod Seal and Wiper
  Requires no adjustment
  Assures longest possible trouble-free operation
- Cushion Adjustment Screw and Ball Check...
  Maintains minimum head dimension
  Identical seats provide interchangeability
- Bore sizes from 1½" through 12"
- 18 Standard mountings
- More power per dollar

Ask for Catalog 103... It contains complete Data and Dimensions.

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A8-631½

tained from ASM headquarters, Metals Park, Novelty, Ohio.

May 3-5—
National Association of Relay Manufacturers. Eighth Annual Conference on Electromagnetic Relays to be held at Oklahoma State University, Stillwater, Okla. Additional information is available from Prof. Charles F. Cameron, P. O. Box 6, Stillwater, Okla.

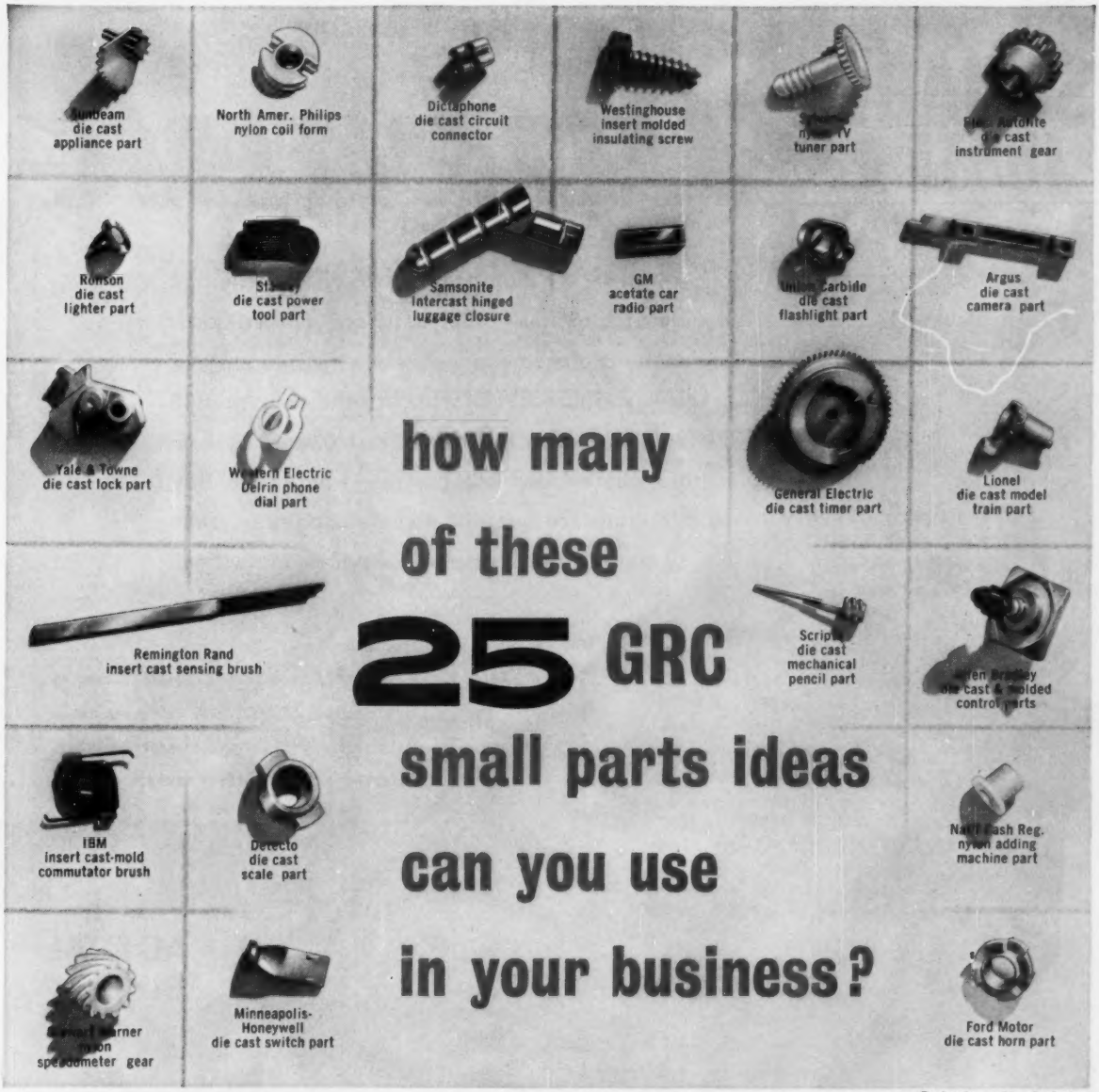
May 3-5—
Western Joint Computer Conference to be held at the Jack Tar Hotel, San Francisco. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Association for Computing Machinery. Further information can be obtained from William C. Estler, 965 Lincoln Ave., Palo Alto, Calif.

May 9-11—
National Fluid Power Association. Spring Meeting to be held at the Grand Hotel, Point Clear, Ala. Additional information is available from Barrett Rogers, executive secretary of NFPA, 5595 N. Hollywood Ave., Milwaukee 17, Wis.

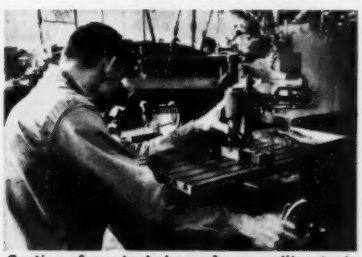
May 9-12—
Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Civic Auditorium and Brooks Hall, San Francisco. Further information can be obtained from society headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

May 17-19—
American Society of Mechanical Engineers. Production Engineering Conference to be held at the Hotel Schroeder, Milwaukee. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

May 23-26—
Design Engineering Show and Conference to be held at the Coliseum, New York. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.


Sunbeam die cast appliance part
North Amer. Philips nylon coil form
Dictaphone die cast circuit connector
Westinghouse insert molded insulating screw
die cast instrument gear
Ronson die cast lighter part
die cast power tool part
Samsonite intercast hinged luggage closure
GM acetate car radio part
Argus die cast camera part
Yale & Towne die cast lock part
Western Electric Delrin phone dial part
how many
of these
25 GRC
small parts ideas
can you use
in your business?
General Electric die cast timer part
Lionel die cast model train part
Remington Rand insert cast sensing brush
die cast mechanical pencil part
IBM insert cast-mold commutator brush
Detecto die cast scale part
Ford Motor die cast horn part

Parts shown ½ actual size



Section of our tool shop, where quality starts for GRC TINY ZINC ALLOY DIE CASTINGS and ENGINEERING THERMOPLASTIC MOLDINGS

They are, truly, Shapes of Progress... tiny components that mark Gries' significant and recognized strides in die casting and molding small parts. Each makes a better, more profitable product possible. Yet none could have been made with such high quality... so economically... without GRC's specialized capability: the combination of design experience and unique automated facilities.

What about your idea... your product? GRC gives you design flexibility you may never have thought possible... precision and savings thru 25 years of die casting and molding tiny parts exclusively. *No size is too small... no design too intricate to consider.*

We welcome your inquiries... and offer several significant booklets to help expand your design horizons. Won't you write?

NO SIZE TOO SMALL!
Maximum sizes up to 1¾", ½ oz.

25 *Twenty-five Years of Progress in Tiny Parts Design and Production.*

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WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

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Circle 427 on Page 19

SQUARE D announces NORpak

NORpak is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers—all without contacts or motion of any kind. Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, NORpak offers the important advantages shown on the next page . . . . .

ACTUAL SIZE

SQUARE D COMPANY

—A SIMPLER, FASTER, STATIC CONTROL!

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit. **NORpak** is *not* complicated—it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

UNMATCHED SPEED

NORpak provides switching at rates up to 25,000 per second—faster than any other industrial static system.

SMALLEST COMMERCIAL PACKAGES

NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

EXTRA DEPENDABILITY

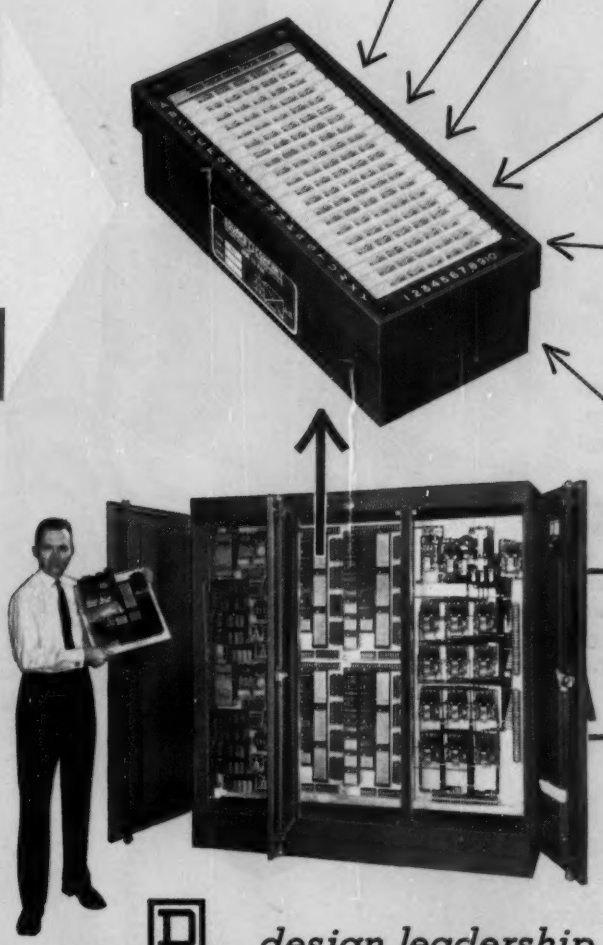
NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak,** can give you on-the-spot answers to any application questions.



NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

● *Write for the complete story on* **NORpak** *—its theory, application and operation. Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin*

D ...design leadership

wherever electricity is distributed and controlled

ALL NEW!

The GABRIEL CONTROL VALVE

Performs the same work as valves 5 times its size and weight!

Compact and lightweight, the Gabriel control valve offers all these outstanding features in one *really new* design:

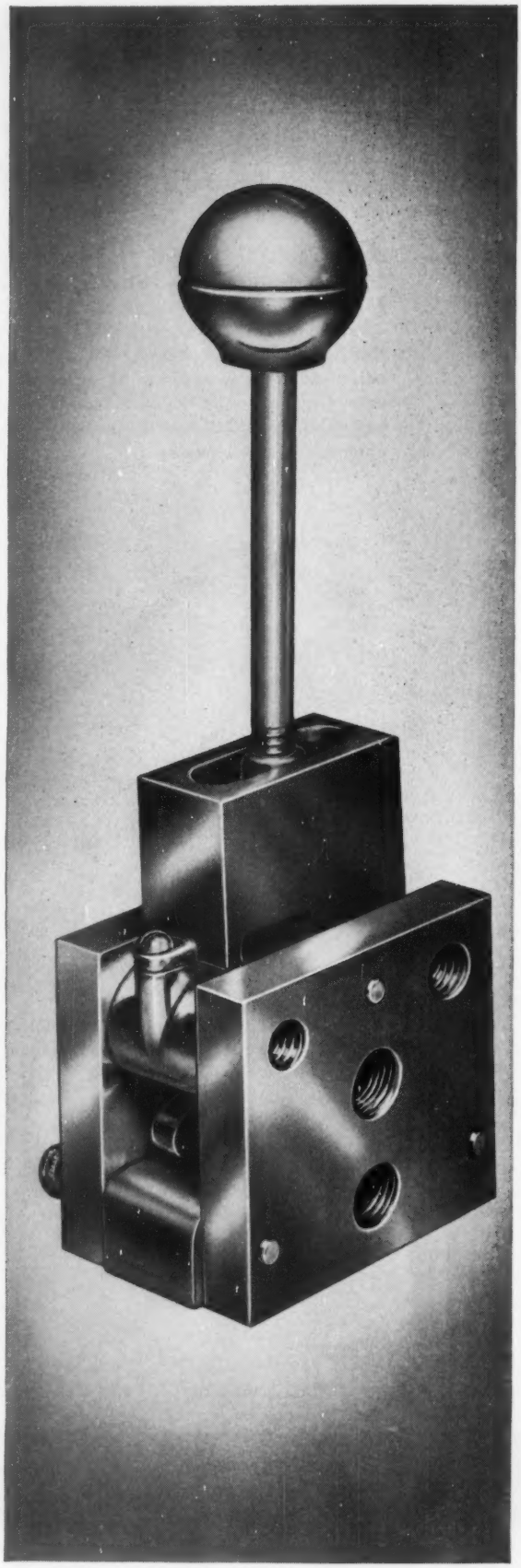
- **Optional porting**
- **For use with air, vacuum, water or oil**
- **Low pressure drop**
- **Full flow-through**
- **Fail-safe return to neutral or closed**
- **Built-in relief for excess pressure**
- **For applications from vacuum to 1500 psi**
- **Quick response (from closed to open in .0013 sec.)**

Less than 2 lb. operating pressure is required on actuator, assuring sensitivity and ease of operation. The new Gabriel valve provides directional control with built-in flow control. Both 3-way and 4-way valves are available—for manual, cam actuated, single or double solenoid operations. Valves have adapter plates to permit various piping arrangements or operations of single or double cylinders without using tees. Valves may be stacked in sandwich construction to provide a compact bank or mounted on standard manifold blocks, subplates or pipes.

For more information, write for technical literature

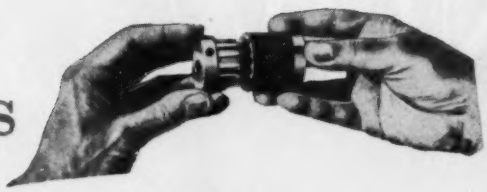
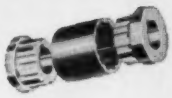
Gabriel
VALVE DIVISION

The Gabriel Company · 1148 Euclid Ave., Cleveland 15, Ohio



Circle 429 on Page 19

US RUBBER **PowerGrip** FLEXIBLE COUPLINGS

These couplings  are so simple in design  that their cost is LOW compared with other couplings. Insist on having U.S. PowerGrip Flexible Couplings tried on your machinery and then watch your costs go down. Installation is quick and easy. No maintenance, no lubrication. Call now!

The only way to get expert transmission engineering is through your U.S. Rubber Transmission Distributor.

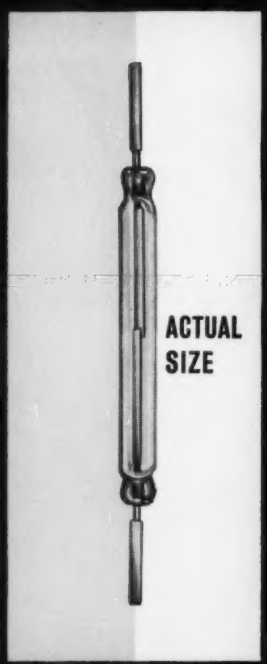
US RUBBER Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

NOW from C.P. Clare & Co...



Switch capsule of the new Clareed Sealed Contact Reed Relay consists of a pair of magnetically operated contacts, hermetically sealed in a glass capsule, in an atmosphere of inert gas.

SPECIFICATIONS

Contact Arrangement: Normally form A, form B, in combination form C

Overall length: 3-¼ in. max.

Outside diameter: 0.215 in. max.

Contact material: Gold

Contact rating: 15 volt-amperes max., non-inductive: 1 amp. max.; 250 volts max.

Contact resistance: 25-40 milliohms.

Life expectancy: At 14 volt-amperes (½ ampere, 28 volts dc), 20,000,000 operations.
At 7 volt-amperes (¼ ampere, 28 volts dc), 100,000,000 operations.

Minimum breakdown voltage: (60 cps) 500 volts rms.

Insulation resistance: 500 k megohms min.

Low level load test: 8 microamps, 800 ohms, 250 millivolts, open circuit operated at 3 ips, 100 million operations with no failures.

Switches per Coil	Watts to Just Operate Typical Coils	Milliseconds (including bounce) Operate Excess NI over P.U. 100	200	Release
1	0.25	1	0.8	0.25
2	0.30	1.5	0.9	0.25
3	0.35	2.2	1.5	0.25
4	0.42	3.2	2.2	0.25
5	0.52	3.5	2.5	0.25
6	0.8	5	3.5	0.50
12	1.5	6	5	0.50
20	3.5	8	6	0.50

CONTACT BOUNCE

At "just operate"	0.3 ms max.
At 200 excess NI	0.5 ms max.
At 400 excess NI	0.8 ms max.
No bounce on release.	

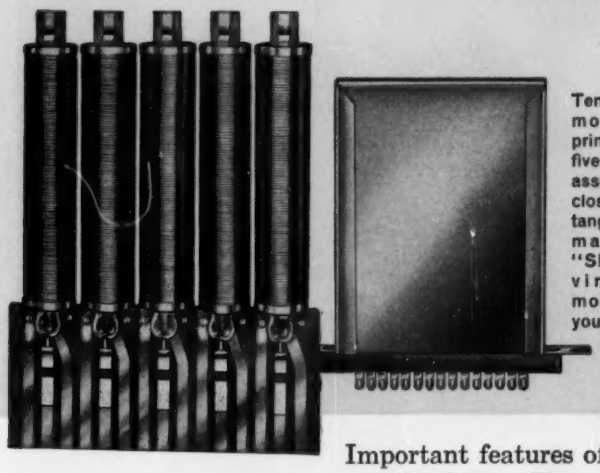
...CLAREED®

a New Concept in Relay Design

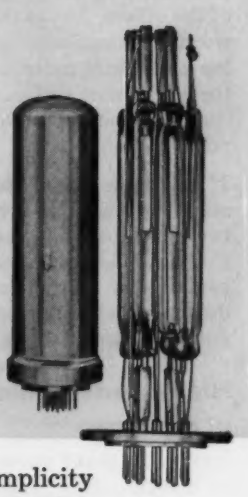
The new CLAREED Sealed Contact Reed Relay effectively eliminates contact contamination. With its contacts hermetically sealed in contaminant-free inert gas, this new design assures millions of perfect operations. Hundreds of millions are possible when operated at up to ½ rated contact load.

CLAREED relays are ideal components for transistor drive applications and for use in computers and data processing equipment. Their low inductance and the low inductance change in the operating coil at each operation limits the transients produced. Submit your packaging problem for recommendations.

• PACKAGED TO MEET *your* REQUIREMENTS



Ten CLAREED switches, mounted in line on a printed circuit board with five magnetic coils. This assembly can then be enclosed in the flat, rectangular container or it may be coated with "Skin-Pack," a tough vinyl plastic, and mounted directly into your equipment.



Six CLAREED switches clustered for mounting in a single tube container.

Important features of CLAREED relays are their simplicity and flexibility. They may be mounted to meet the requirements of almost any application and environmental condition, even on your own printed circuit board—to comply with your mechanical design configurations.

CLAREED relays are as flexible as your application requires. Consultation with your nearby CLARE sales engineer is invited. Additional information may be obtained from C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC 5.*

SEE IT AT THE IRE SHOW
New York Coliseum
March 21-24
BOOTH NOS. 2218 & 2220

CLARE FIRST in the industrial field

Circle 431 on Page 19

Now specify chrome plate that LASTS 30% LONGER!

New JERVIS Duplex-Nickel Process Practically Eliminates Corrosion and Tarnishing of Plated Parts

Fact: Parts that are Jervis duplex-nickel plated last up to 30% longer than ordinary one-coat nickel platings! Fact: at least two major automotive manufacturers have specified double-nickel plating for all the chrome plated exterior trim for their 1960 model cars! Their tests have proven that it looks better, longer!

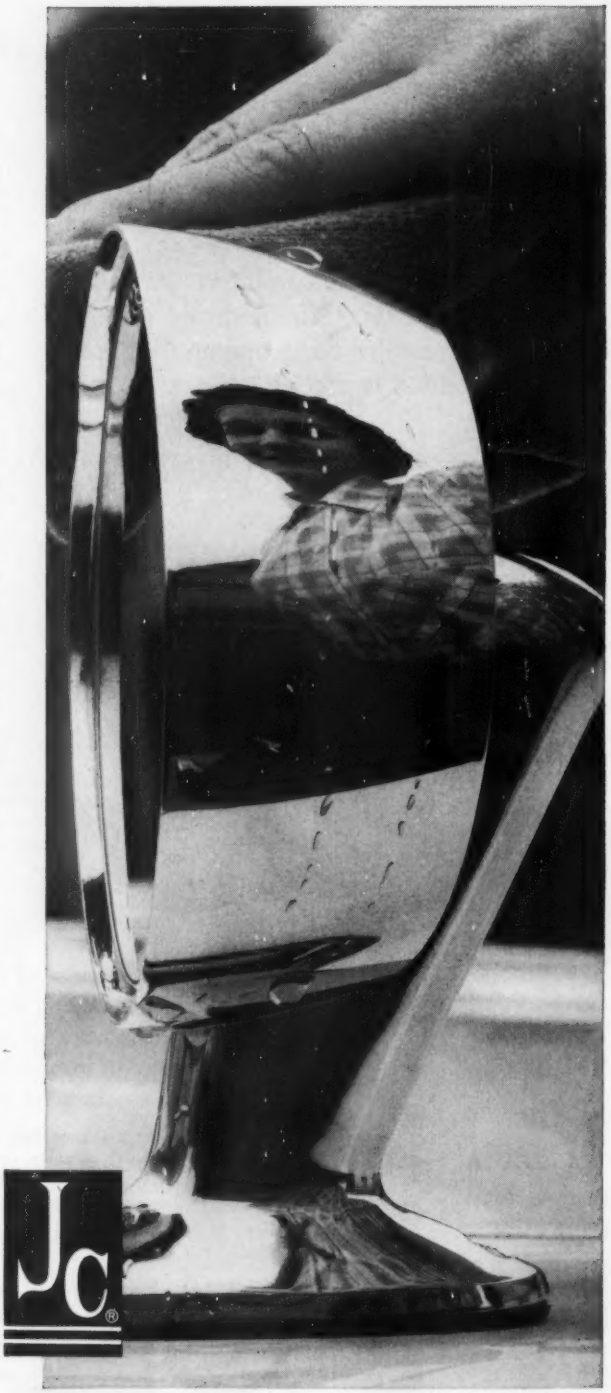
What's Special About the Jervis System?

Jervis double-nickle plating (called Jervis Duplex-Plating) is *more* than just two coats of nickel sandwiched between the copper base coat and chrome finish coat. With the duplex plating equipment, the *grain* of each nickel coating is laid at a right angle to the grain of the others, just as the wood layers in a sheet of plywood are joined with opposing grains. This grain-overlap gives extra protection to both the base metal and the fine chrome surface finish . . . practically eliminates corrosion and tarnishing . . . adds extra years of life to your plated parts.

If you are a user of chrome plated parts which must stand up under severe weathering conditions or the corrosive action of salt water, contact the Jervis Corporation today. As a leading producer of plated products . . . and as a pioneer in the installation of duplex-nickel equipment . . . Jervis will provide a fast and economical answer to your plating problems.

High-Grade Plating and Anodizing of All Types

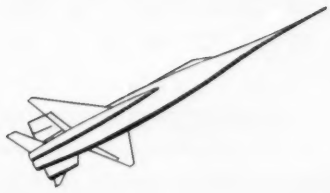
Jervis does many other types of plating and anodizing on a high-quality, high-production basis. Our equipment includes both hand-lift and automatic anodizers, automatic copper-nickel-chrome plating equipment, an automatic duplex-nickel plater, and an extensive custom brass and copper plating set-up. Solve your plating problems by asking for a Jervis bid today. And write for the free brochure "This is Jervis," describing our complete stamping, casting, and finishing facilities.



JERVIS

JERVIS CORPORATION, Dept. MD, Grandville, Mich.

Circle 432 on Page 19



For "particular" parts– at a price not previously possible

CHECK ROCKRITE® SPECIAL-FORMED TUBING

All costs considered, with parts that require special shapes, properties or other characteristics, substantial savings can be yours in the ROCKRITE method. Economies in stock and machining — an improvement in strength-weight ratios and simplified fabrication are typical advantages of ROCKRITE. As an example, this 20-foot aircraft spar is step-tapered from 2.885" to 1.250" O.D. with wall thickness controlled between .313 and .326 at one end and .049/.055 at the other—all with defect-free quality. Other tubular shapes achieved with ROCKRITE include:

RIBBED TUBING—*illustrates ability to work in rare metals and non-symmetrical configurations and eliminate machining and waste of expensive stock.*

SAE 52100 STEEL—*close tolerance and improved machinability for high-speed production of anti-friction bearing raceways.*

SPECIAL BORE TUBING—*bore shapes available: square, triangular and hexagonal, with very slight radius corners.*

ROCKRITE® TUBING

Full details, of critical interest in solving your tubular parts problems, in Technical Bulletin SP-1. Write for your copy today—no obligation.

TUBE REDUCING CORPORATION

A SUBSIDIARY OF AMERICAN METAL PRODUCTS COMPANY

MAILING ADDRESS: P. O. Box 959M, Passaic, New Jersey
520 Main Avenue, Wallington, New Jersey

9-513

Circle 433 on Page 19

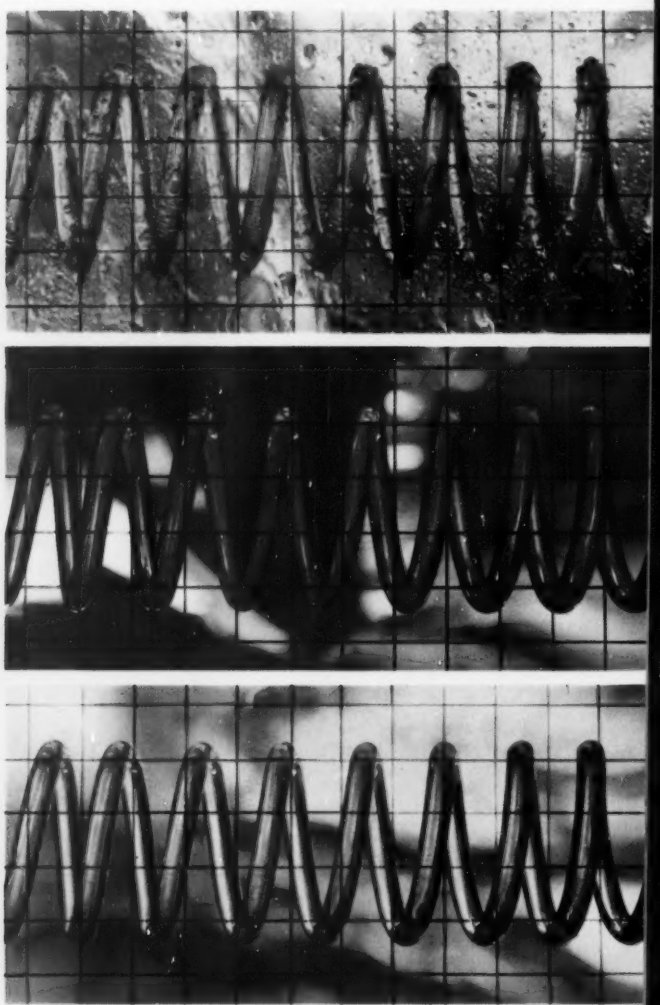
Circle 434 on Page 19→

NEW NEW MERLON® NEW

POLYCARBONATE

EXCEPTIONAL MECHANICAL STRENGTH
(Example: 12 to 16 ft-lb/in. notched Izod impact strength—see table)

SUPERIOR DIMENSIONAL STABILITY
(Example: Low Water Absorption—see table)



the new thermoplastic with the most profitable combination of functional engineering properties!

New MERLON combines in one material the most sought-after engineering properties near the ultimate specification level. It is not only a new thermoplastic resin, but represents a new approach to the whole material specification assignment in industry.

In addition to the major properties illustrated, MERLON polycarbonate is transparent, has low water absorption, is non-staining, self-extinguishing, odorless and tasteless. It can be fabricated by injection molding, extrusion, and vacuum forming on stand-

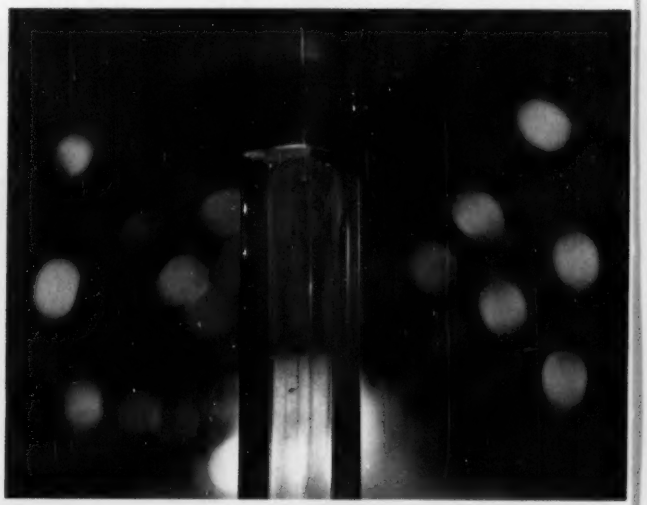
NEW NEW NEW

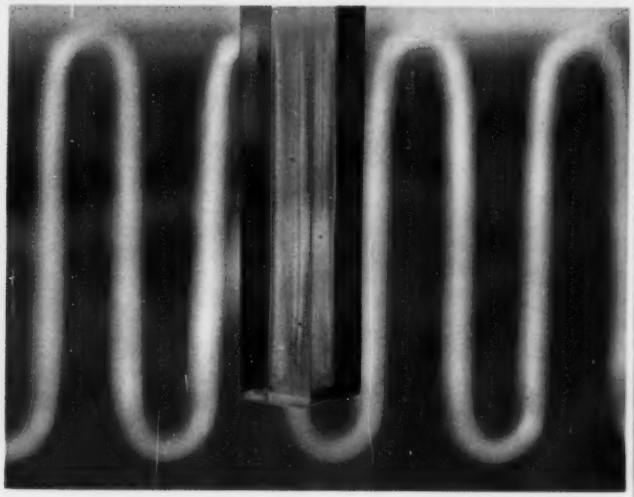
GOOD ELECTRICAL PROPERTIES

(Example: 440 volts/mil dielectric strength, short time—see table)

OUTSTANDING THERMAL RANGE

(Example: Tensile strength 10,200 psi at –60°C, 8200 psi at 100°C)





ard equipment. Finished parts have brilliant sur
gloss, can be machined, sawed, cut or stamped; e
bonded with appropriate solvents; readily heat we
or sealed. Plasticizers are not necessary; dyes
pigments can be added for a full range of transpa
or opaque colors.

Examine MERLON's qualifications shown in
chart under the flap of this advertisement—che
against "problem" materials you may now be u
It's very possible that MERLON is the optir

A product of

MOBAY

Mobay Products Company
subsidiary of
Mobay Chemical Company

LIFT THIS FLAP FOR MORE INFORMATION

NEW NEW NEW M

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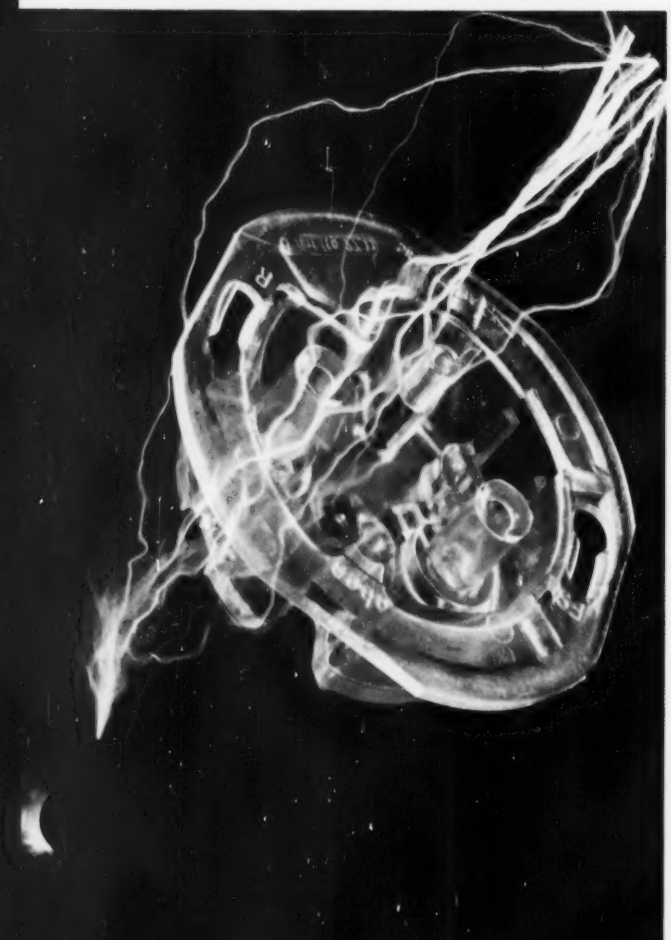
GOOD ELECTRICAL PROPERTIES

(Example: 440 volts/mil dielectric strength, short time—see table)



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ard equipment. Finished parts have brilliant surface gloss, can be machined, sawed, cut or stamped; easily bonded with appropriate solvents; readily heat welded or sealed. Plasticizers are not necessary; dyes and pigments can be added for a full range of transparent or opaque colors.

Examine MERLON's qualifications shown in the chart under the flap of this advertisement—check it against "problem" materials you may now be using. It's very possible that MERLON is the optimum

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MERLON® POLYCARBONATE NEW NEW

PROPERTIES OF MERLON® POLYCARBONATE RESIN

PROPERTY	ASTM NO.	VALUE*
MECHANICAL		
Impact strength, Izod (notched)	D-256 (½" x ½") (½" x ⅛")	2 to 3 ft-lb/in. 12 to 16 ft-lb/in.
Tensile strength and yield point	D-638	8,000-9,000 psi
Elongation, at yield	D-638	5-6%
Elongation, ultimate	D-638	60-100%
Compressive stress at yield point	D-695	12,000 psi
Deformation under load	D-621	0.14%
Flexural strength	D-790	11,000-13,000 psi
Modulus of elasticity		
Tension	D-638	2.8-3.2 x 10^5 psi
Flexural	D-740	3.2-3.4 x 10^5 psi
Rockwell hardness	D-785	R 115
ELECTRICAL		
Dielectric constant	D-150	
60 cycles		2.95
10^6 cycles		2.90
Dielectric strength, short time	D-149	440 V/mil
Dissipation factor		
60 cycles	D-150	0.0007
10^6 cycles		0.0100
Volume resistivity		
Dry		1.2 x 10^{16} ohm/cm
4 days at 80% rel. humidity		9 x 10^{14} ohm/cm
Arc resistance	D-495	12 sec

PROPERTY	ASTM NO.	VALUE*
THERMAL		
Heat distortion	D-648	
264 psi		280°F
66 psi		290°F
Specific heat		0.28 cal/°C/gm
Coeff. of expansion	D-696	7 x 10^{-5} in./in./°C
Melting temperature		425-440°F
Crystalline melting temp.		505°F
Flammability (in./min)	D-635	Self-extinguishing
MISCELLANEOUS		
Specific gravity	D-792	1.20
Refractive index	D-542	1.587 N_D25°C
Clarity		Transparent
Water absorption 24 hr immersion	D-570	0.3%
Effect of sunlight		None to slight
Outdoor aging		Good

*These values have been obtained under standard ASTM and laboratory test conditions. As averages, these values do not necessarily represent minimum material specifications.

aterial you've been searching for. MERLON's full nge of engineering properties opens the door to a de variety of redesign possibilities that could mean wer cost and improved performance of your prod- ts and components.

Test sample quantities of this new resin are now ailable for your development studies. Test appli- tion data and property tables (based on more than e years of research and development work here and road) are available. Mail coupon for your copy today.

CLIP AND MAIL THIS COUPON FOR LATEST INFORMATION

Mobay Products Company, Dept. 606
1815 Washington Road
Pittsburgh 34, Pa.

Please send your Bulletin No. M1.
I represent a ☐ manufacturer, ☐ molder, ☐ both.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

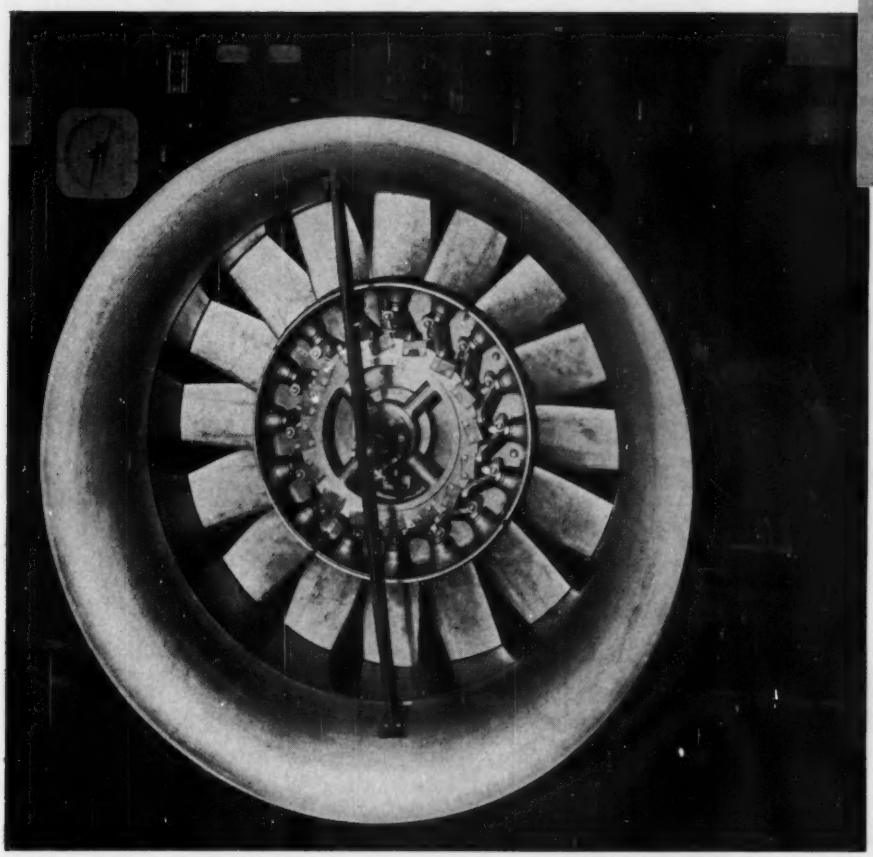
If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

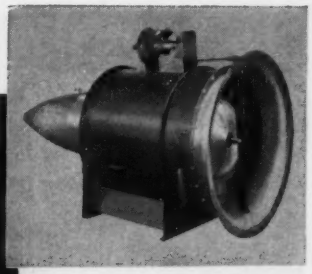
- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN





Pneumatic control valves permit simultaneous adjustment of the output of any number of fans. Simple mechanical linkage controls pitch of fan blades.

Joy Design Means:

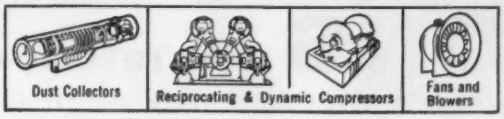
REMOTE CONTROL OF FAN BLADE PITCH—FAN OUTPUT

Joy Controllable-Pitch Fans are designed to permit adjustment of fan blade pitch by remote control, in response to varying fan output requirements. A simple mechanical linkage maintains perfect calibration of all blades, and gives instant response to the control device. Blade pitch can be changed while the fan is running. The control can be manual, or the linkage in the fan can be tied to sensing devices which automatically change fan output in response to changes in humidity, temperature, CO_2 concentration, etc. Should large volumes of air or gas be involved, any number of the fans can be controlled simultaneously by means of pneumatic valves.

Joy Controllable-Pitch is much more efficient than dampers or variable inlet vanes in varying fan output. Fan motors always run at their most efficient speeds, and there are no aerodynamic losses. In addition, the basic vane-axial design of the Joy fans provides greater aerodynamic efficiency than propeller and centrifugal types.

For accurate, efficient control of variable fan output, you can't beat the Joy Controllable-Pitch Fans. Response to controls is accurate and instantaneous, and fan efficiency is high at all levels of output. For complete details, write for Joy Axivane Fan Bulletin 1214-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

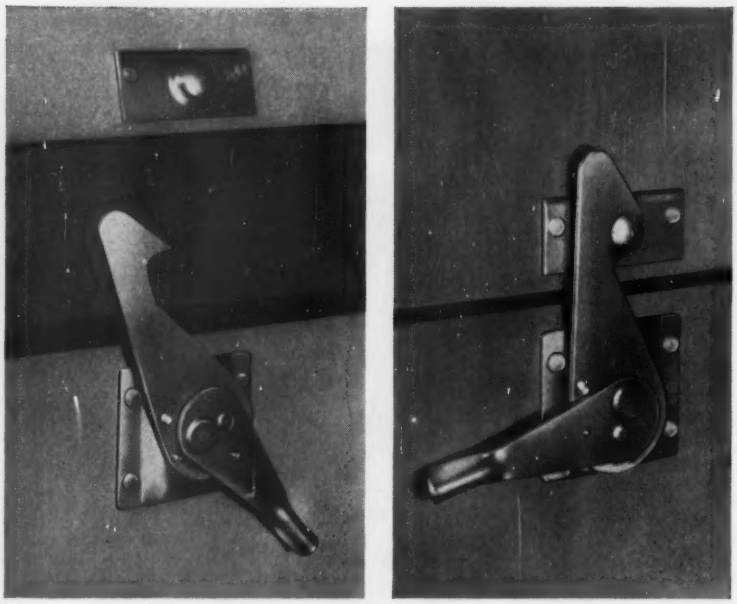
In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

1214

Circle 435 on Page 19

WHAT HOOK-LOCK IS

HOOK-LOCK is a springless, positive-locking latching device which is ideally suited for use on rigidly specified military transit cases as well as less expensive commercial containers. It provides high closing pressure and tremendous load-carrying capacity...is impact and shock-proof. HOOK-LOCK is so designed that it lies flat against the mounting surface whether in open or closed position. Since operation is parallel to mounting surface, no space for operating clearance is required.

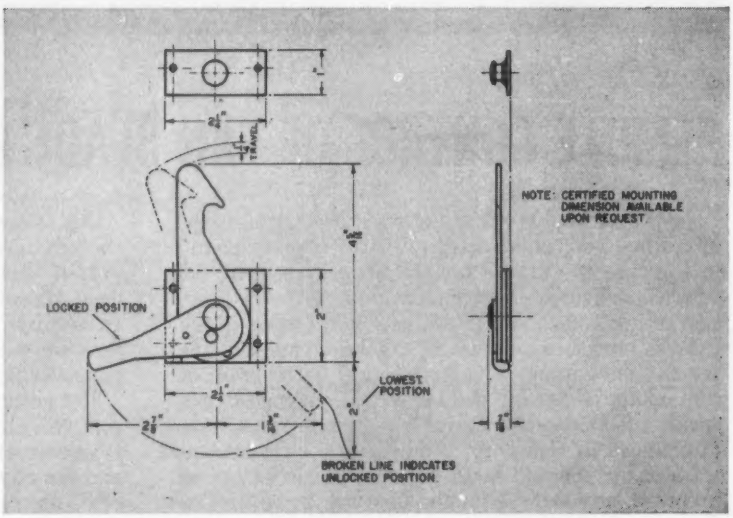


HOOK-LOCK lies flat against mounting surface, open or closed.

New—HOOK-LOCK container latch...It's flat!

FEATURES

- Shock-proof—solid construction...withstands high impact blows *directly on the fastener.*
- Closing pressure of 200 lb. Where needed, pull-down pressure can be substantially increased by modification of operating lever.
- Tensile load capacity: 750 lb.
- Compact—lies flat open or closed. Extends just 7/16" from container surface at thickest point.
- Positive-locking and springless. Unaffected by arctic temperatures.
- No operating clearance required, because hook and lever move parallel to mounting surface.



IF YOU have questions regarding the possible application of HOOK-LOCK or other Simmons industrial fasteners to your particular needs, your inquiry will receive our immediate attention. Contact your nearest Simmons office or write direct.

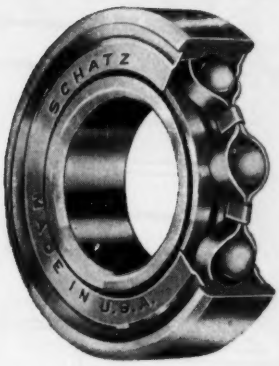
SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

See our 8-page catalog in Sweet's Product Design File

Name your load and speed combinations...

Schatz makes the most varied line of Ball Bearings to fit your needs



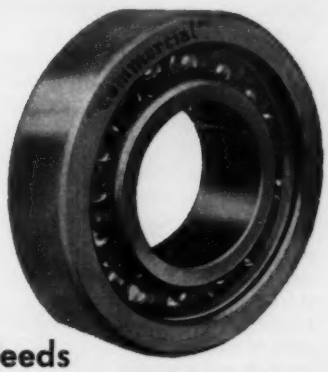
"Functional Precision" Ball Bearings—BR series

One piece race type with ball cage. Designed to give all the precision you require under certain ratios of load, speed and life expectancy. Available in open type, single or double shielded, single or double sealed with Schatz patented low friction plastic seal. Or with one shield and one seal on special order.

23 sizes from $^{3}/_{16}$" to 1"—6 types in each size + specials

"Commercial" Ball Bearings

The most complete and varied line anywhere.



UNGROUND BALL BEARINGS "TYPE A"—Every standard type—radial, thrust and radial thrust.

GROUND BALL BEARINGS "TYPE B"—Used and recommended where greater accuracy and smoother running qualities are needed and where loads are heavier and speeds higher.

1033 sizes to match your Bearing Application Needs

• See our Catalog in SWEET's

FILL IN AND MAIL

We'll fit these bearings—or special types and sizes to your special needs. Just fill in your application problem below—attach to your letterhead and mail.

THE SCHATZ MANUFACTURING COMPANY, Poughkeepsie, N. Y.

Here's our bearing problem. What do you suggest?

APPLICATION_____

LOAD (radial, thrust or both)_____

SIZE_____

SPEED_____

LIFE FACTOR_____

OPERATING CONDITIONS_____

SPECIAL CONDITIONS_____

Name_____ Title_____

Company_____

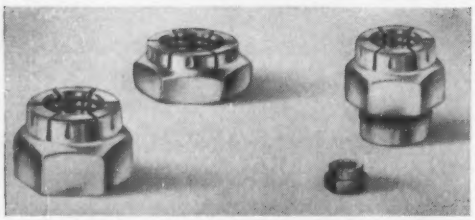
Address_____

City_____ Zone_____ State_____

SCHATZ
BALL BEARINGS

Self-locking nut that locks without seating,

FLEXLOC



Left to right: full height, thin, microsize, clinch nut.

Three of the most significant features of 1-piece all-metal FLEXLOCs: they are self-locking; they lock without seating; they won't work loose, regardless of vibration.

With FLEXLOC no lockwashers, jam nuts, cotter pins or other auxiliary locking devices are needed. There's nothing extra to put together, come apart or get lost. Your design problem is simplified. Assembly time and costs are reduced. And maintenance expenses are lowered because FLEXLOCs can be readily removed and repeatedly re-used.

What's more, since FLEXLOCs lock without seating, they serve as stop nuts, staying put anywhere on bolt or stud once 1½ threads of bolt are past top of FLEXLOC. And there's no need to worry about the effect of "shake, rattle or rock" on FLEXLOCs. They just won't budge, even in the face of terrific impact, ceaseless vibration.

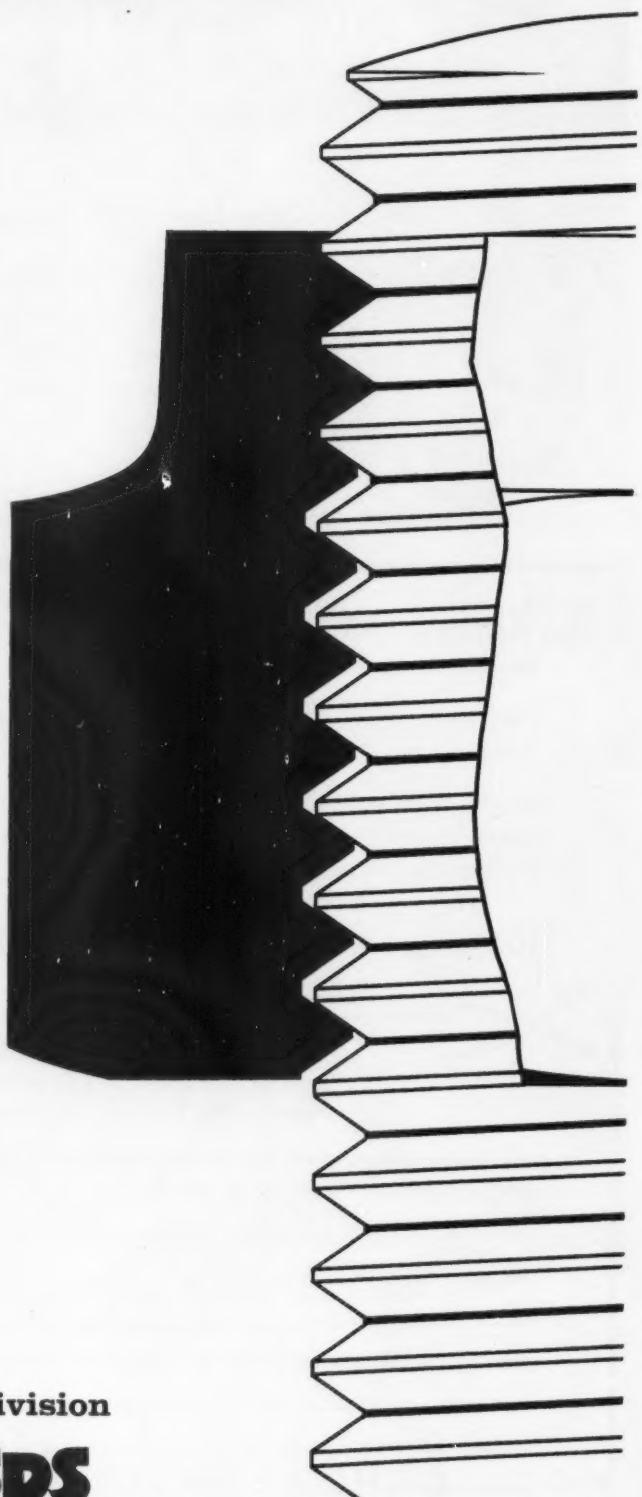
FLEXLOC Clinch Nuts—Designed for use in thin-section materials, they make blind fastening easy, are ideal where dismantling and reassembly is required. They are simply clinched into the material to be assembled and become an integral part of it. Use FLEXLOC Clinch Nuts in place of anchor, weld or cage nuts.

See your authorized SPS distributor for complete information on sizes, materials and finishes. Or write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

FLEXLOC Nuts

PRODUCT	SIZES
Full Height	#2 through 2"
Thin Type	#6 through 1½"
Microsize	#0 through #4
Clinch—regular	#4 through 5/16"
Clinch—microsize	#0 through #4

Regular clinch nuts come in 7 shank lengths, microsize clinch nuts in 2



INDUSTRIAL FASTENER Division

JENKINTOWN 18, PENNSYLVANIA

SPS

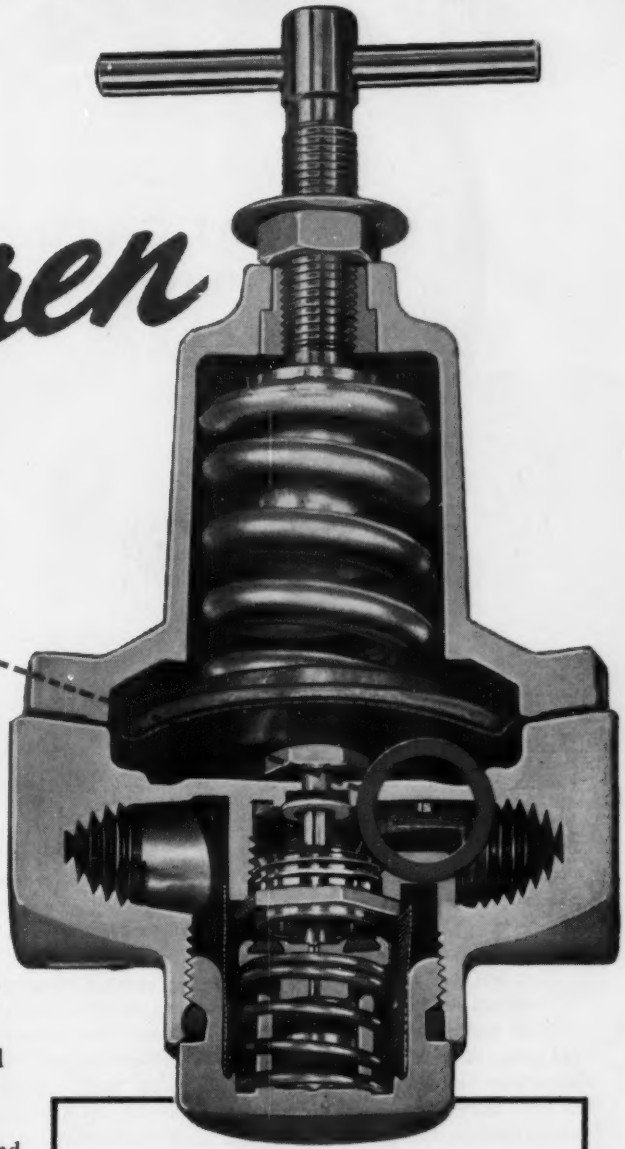
where reliability replaces probability

All Pressure Regulators are not alike

Norgren

Baffle and Siphon Tube Construction

provides more uniform regulated pressure as flow demand changes



In the ideal pressure regulator there would be no change in the regulated pressure no matter how wide the variations in the flow rate.

Norgren Pressure Regulators approach this ideal by providing a baffle and siphon tube feature. This increases the sensitivity of the valve to changes in the flow rate through the regulator and provides better performance and a more uniform regulated pressure over a wide range of flow rates.

The baffle protects the diaphragm from pressure shock and abrasive action. This gives you longer regulator life, more dependable operation and minimum maintenance.

For complete information on all your regulator needs, ⅛" to 2", call your nearby Norgren Representative listed in your telephone directory- or WRITE FACTORY FOR DESCRIPTIVE LITERATURE.

Norgren Pressure Regulators give you these important features:

- Balanced Valve Construction — improved regulator performance
- Large Nylon-reinforced Buna N Synthetic Rubber Diaphragm — long service life
- Baffle Plate and Siphon Tube — increased accuracy
- Large Passages and Valve Openings — large flow capacity
- Easy servicing while still on air line
- Flexible Valve Pin — assures better seating

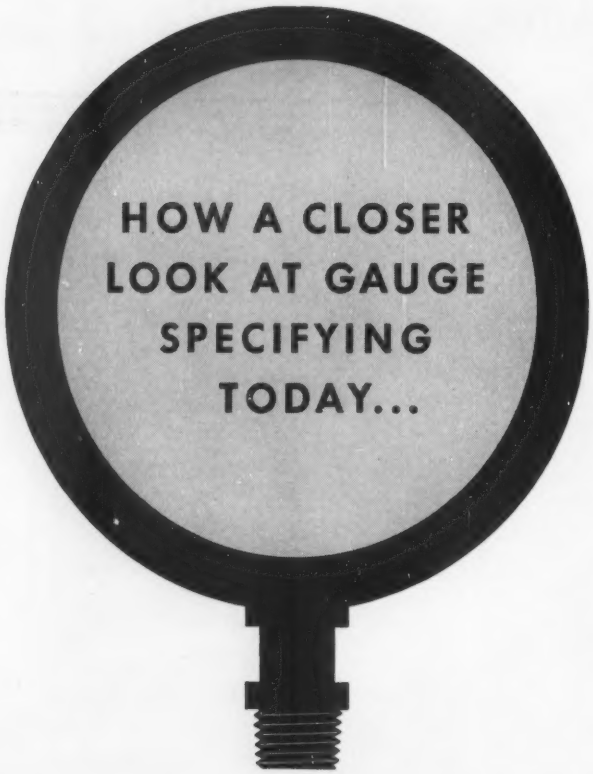
FOUNDED IN 1926

C. A. NORGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

2601

Circle 440 on Page 19



can keep you up on keeping gauge costs down

If you have a new product coming up, or design changes for a present product, and need *any* type of pressure gauge . . . you will get your gauge faster and save more by checking United States Gauge first. For these reasons:

First, USG has 50,000 standard gauges to draw on. Second, USG knows thousands of modifications possible with standard gauges to meet special design requirements more economically. Third, the men at USG know your competitive need to design better performance into equipment and deliver faster, while reducing costs.

Finally, at USG you will get exactly the gauge accuracy and performance you want for your purpose and price . . . up to and including the finest high-precision test gauges made.

Today, USG gauges are specified by 6 out of 10 original equipment manufacturers. For a closer look at dependable performance and lower costs in your next gauge need, call your USG distributor, listed in the Yellow Pages. Or write direct to United States Gauge.

UNITED STATES GAUGE

Division of American Machine and Metals, Inc., Sellersville, Pennsylvania

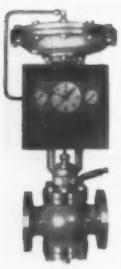
Find Your Nearest Distributor in the 'Yellow Pages'

Test Gauges

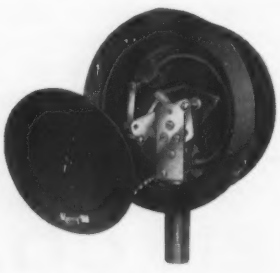
Pneumatic Receivers

Recorders and Recorder-Controllers

Drawn Case Gauges (Brass or Steel)



Indicating "Pilot" Controllers and Transmitters



Solfrunt® (Supergauge) with blow-out back

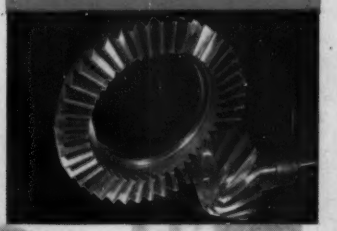
Supergauge® (A.S.A. Grade AA) Line

A-Line (A.S.A. Grade A) Gauges

Drawn Case Thermometers, too

Circle 441 on Page 19

PLANOID® GEARS are low-ratio gears competitive with bevel and hypoid gears in efficiency and performance, but are manufactured at lower cost.



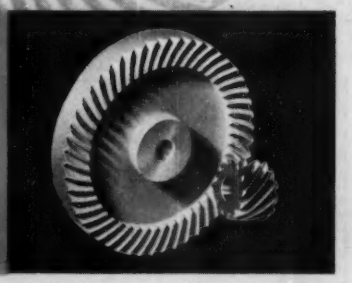
From Illinois Tool Works' unique family of gears . . .

SPIROID® GEARS

new gear economies

with new gear efficiencies

HELICON® GEARS bring even greater production economy to high quantity applications than is possible with face, bevel or worm gears.



Shown here are typical examples of outstanding developments in right-angle gearing introduced by Illinois Tool Works. Pictured above is a Spiroid gear, the first major advancement in gearing in thirty years.

Spiroid® Gears do the same job as worm gears with this notable exception: they do it more economically and more efficiently in less space. They are recommended for application in the field of medium to high-ratio right-angle gearing. For maximum economy they may be sintered, molded or cast in metal or plastic; however, even hardened steel Spiroid gears for maximum power transmission are manufactured more cheaply than worm gears.

SEND TODAY FOR THESE NEW GEAR BOOKLETS Free booklets are available giving complete information on the design, manufacture, applications and advantages of each of these gears. Request your copies today.

Spiroid® gears

SPIROID DIVISION OF ILLINOIS TOOL WORKS

Circle 442 on Page 19

2501 North Keeler Avenue, Chicago 39, Illinois

itw

Plastic fastened to metal— firm and weather-tight with RIVNUTS®

Large transparent plastic panels form the cockpit windows of the Vertol Aircraft Company's new YHC-1A helicopter. The plastic is firmly secured to the airframe by B. F. Goodrich RIVNUTS. About 300 are installed—quickly and easily—resulting in a finished seal that withstands both vibration and weather extremes.

One man fits the RIVNUTS into the hat section, working from one side. These RIVNUTS act as blind nutplates. Attachment screws tighten the molding strips, rubber and plastic in a firm, weatherproof grip.

This use of blind-fastening RIVNUTS insures a simple and very satisfactory method of window installation. In case after case, RIVNUTS speed assembly, cut labor costs, simplify design. If you'd like recommendations on a specific fastening problem, please send a print of your part.

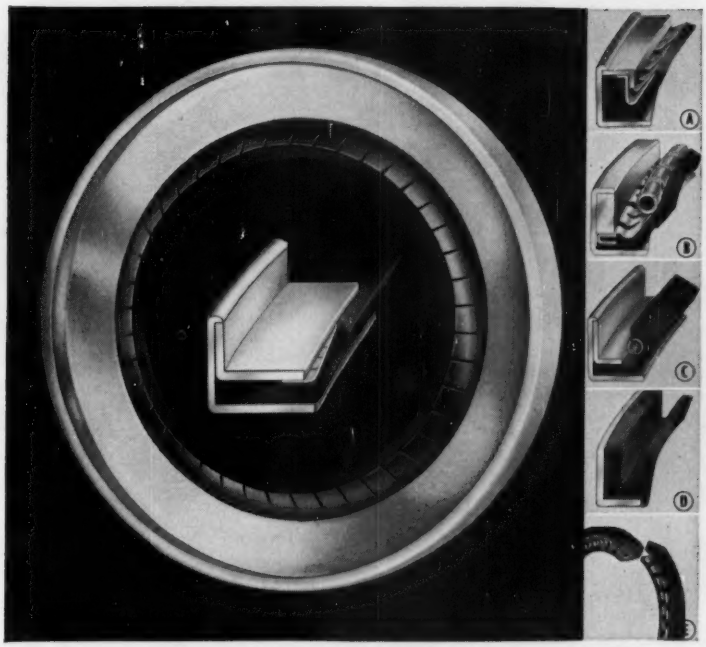
YOU CAN IMPROVE FASTENING IN SHEET METAL, TUBING, TANKS WITH RIVNUTS

New RIVNUT Data Book visualizes how RIVNUTS work, shows construction and ease of installation in many forms or types of materials. For free copy write Dept. MD-3A, *B.F.Goodrich Aviation Products, a division of The B.F. Goodrich Company, Akron, O.*

B.F.Goodrich *aviation products*

Circle 443 on Page 19

OIL SEALS in Design Engineering



KLOZURE Oil Seals are available with (a) finger spring, (b) with combination finger and garter spring, (c) with garter spring, (d) bonded springless, and (e) split.

SELECTING THE SEALING ELEMENT

Efficient and durable oil seals in your product depend largely on selection of the proper sealing element. Following are several KLOZURE* elements that Garlock offers for different applications:

Nitrile Rubber Elements. This special compound is standard on Garlock KLOZURES. Oil resistant, tough, resilient, and free running, it withstands temperatures from −40° to +250° F constant.

Silicone Rubber Sealing Elements used in Garlock KLOZURE oil seals have excellent resistance to low-swell mineral oils and some chemicals. Temperature range from −70° to +450° F.

Viton Sealing Elements.** This new synthetic rubber by DuPont resists oils, fuels, and solvents from −20° to +400° F. Has low compression set, good tensile strength, resists ozone, oxygen and weathering.

Teflon Sealing Elements** resist all fluids except molten alkali metals and fluorine at elevated temperatures. Recommended for use where the KLOZURE will contact strong acids or other corrosive fluids at temperatures from −110° to +500° F.

Whatever your application, designing with Garlock KLOZURE Oil Seals makes good sense. You are assured of consistent high quality and proper design recommendations.

For prompt service contact one of our 26 sales offices and warehouses throughout the U.S. and Canada, or write for Klozure Catalog 30, The Garlock Packing Company, Palmyra, N. Y.

GARLOCK

Canadian Division: The Garlock Packing Co. of Canada Ltd.

Plastics Division: United States Gasket Company

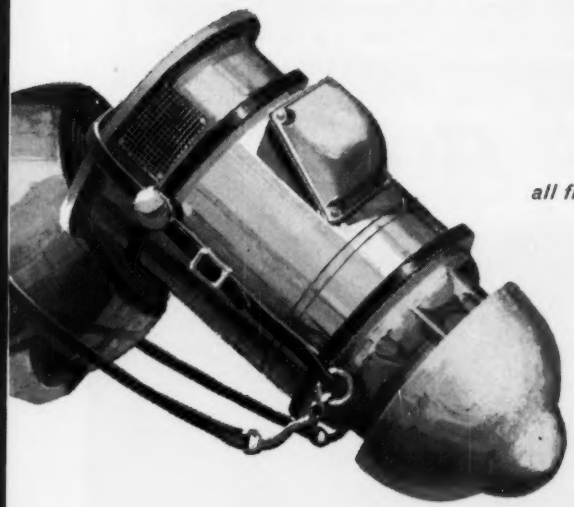
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

*Registered Trademark
**DuPont Trademark

Circle 444 on Page 19

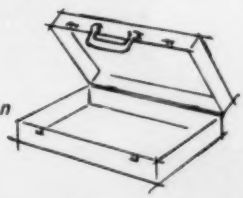
THE CASE OF THE
A. O. SMITH MOTOR MAN

A.O. Smith has the horses!



800 to 1 hp favorites for quiet operation, low maintenance and long-life service...

all from the case of the A. O. Smith Motor Man



The horses of A. O. Smith make up the dandiest remuda an integral motor user ever saw. A complete line of long-lived "easy keepers" — that includes...

SINGLE-PHASE DRIPPROOF INTEGRALS (1-5 hp). Tough rolled-steel frames have mountings harnessed to either old or new NEMA standards. Exclusive *sealed* starting switch keeps 'em running free and easy.

POLYPHASE DRIPPROOF INTEGRALS (1-800 hp). These front-runners are sound of wind, thanks to extra-value ventilation and insulation... sound of limb, thanks to extra care in electrical and mechanical design.

And A. O. Smith delivers the horses! Our motor man near you is on his mark with 24-hour action on all parts and service orders. He'll also show you a complete line of fractional-hp motors.

COPYRIGHT 1960, A. O. SMITH CORP.

Through research ...*a better way*

A.O.Smith
CORPORATION
ELECTRIC MOTORS
Tipp City, Ohio

A. O. SMITH INTERNATIONAL S. A.
Milwaukee 1, Wisconsin, U. S. A.

Circle 445 on Page 19

Just 0.1° F Change Gets Fast Action...

from a Fenwal THERMOSWITCH® Unit

Extreme sensitivity is an outstanding control characteristic of the Fenwal Thermoswitch Unit. Its outer shell is the heat-sensitive element . . . strut-and-shell assembly responds almost instantly to a change in temperature. Contacts are totally enclosed and protected. There's no thermal lag in the unit. *Control is positive and precise.*

Thermoswitch Units are easily adjusted, and cover the range from −100 to +1500°F. They're available as miniature, surface-mounted, or immersion types, with special variations to resist corrosion, extreme vibration, and shock. Current ratings up to 10A-115VAC. *Whichever unit you choose will be rugged and compact — simple, reliable, and inexpensive.*

Build better temperature control into your products with Fenwal Thermoswitch Units. For illustrated booklet, write Fenwal Incorporated, 192 Pleasant Street, Ashland, Massachusetts.

Series 17000
THERMOSWITCH Unit

Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Circle 446 on Page 19

Can You Use BETTER Gray Iron Castings?

Eaton's Continuing Research and Development Programs Assure You the BEST—Engineered to Your Individual Needs

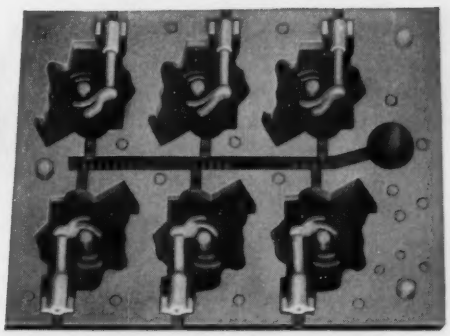
EATON PERMANENT MOLDING

Because of the denser, non-porous, homogeneous structure, Eaton Permanent Mold Castings meet critical quality requirements. The finer dispersion of graphite provides a better material where free machinability and accuracy are essential in critical machining operations. Eaton annealed gray iron castings are available in sizes from one tenth of a pound to fifty pounds.

EATON SHELL CORING

The Eaton process of Shell Coring in permanent mold and shell molded castings provides better internal surface finish and higher dimensional accuracy. Where more than ordinary quality and control of contour are required, the Eaton process offers distinct design advantages and greater uniformity in intricately cored sections.

EATON SHELL MOLDING



Eaton Shell Molding provides more closely controlled metallurgy and hardness for applications requiring pearlitic structures, close dimensional control, and complex designs and contours. Eaton Shell Mold Castings require less machining and finishing, with resulting savings in material, tooling, and shipping.

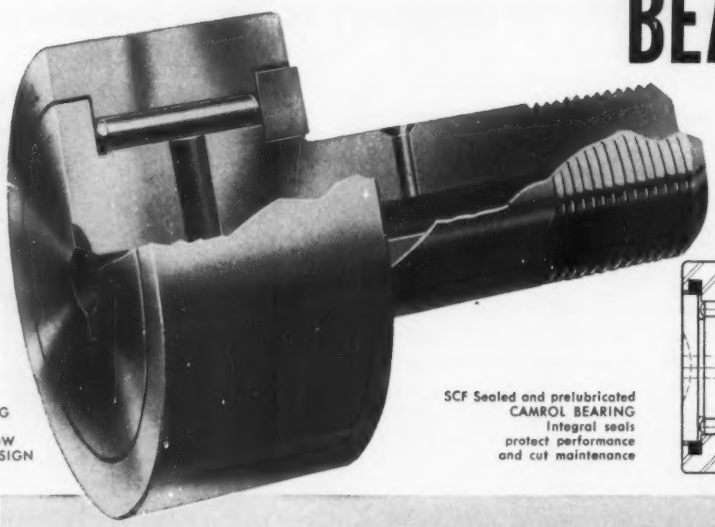
Send for Illustrated Descriptive Literature

EATON

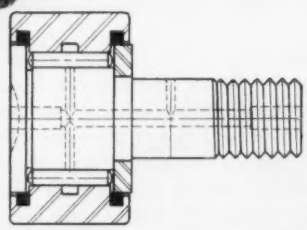
FOUNDRY DIVISION
MANUFACTURING COMPANY
VASSAR, MICHIGAN

Circle 447 on Page 19

McGILL® CAMROL® BEARINGS



CF CAMROL BEARING
CUT AWAY TO SHOW INTEGRAL STUD DESIGN



SCF Sealed and prelubricated CAMROL BEARING
Integral seals protect performance and cut maintenance

SIMPLIFY DESIGN and ASSEMBLY

Stock sizes eliminate the cost of procuring and assembling improvised unit components

You can simplify design and cut cost with CAMROL precision anti-friction cam followers—built for the job. Complete units, with established performance ratings are available from stock in standard roller diameters from ½" to 4". Capacities to 20,480 lbs. at 100 R.P.M.

Precision anti-friction bearing accuracy

Precision construction, including concentricity of stud to outer race OD, provides accurate alignment of machine members.

High load capacity in limited space

A full complement of race width rollers provides maximum capacity and ability to withstand heavy intermittent shock loading. The extra heavy outer ring and specially heat treated stud add durability and insures dependability of machine operation. Bolt mounted ball bearings crack under equivalent loads and plain bearings require constant oil lubrication.

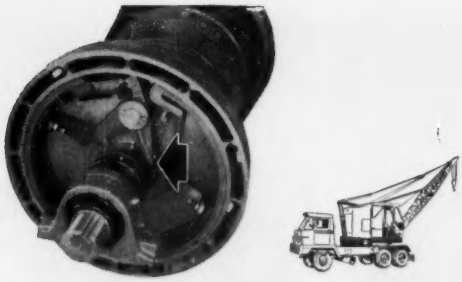
Integral seals retain lubrication —keep dirt out

SCF Sealed CAMROL bearings are interchangeable dimensionally with standard CAMROL bearings. They are pre-lubricated and have a ferrous oxide finish to resist corrosion. Effective sealing against contamination reduces machine maintenance.

Camrol CYR series

In the CYR Series, an inner race replaces the stud for yoke or shaft mounting. Standard and sealed CYR bearings are available in the same stock sizes as CF and SCF Series.

SEND FOR McGILL BEARING CATALOG NO. 52-A. for complete data on McGill CAMROL, GUIDEROL, MULTIROL and CAGEROL bearings.



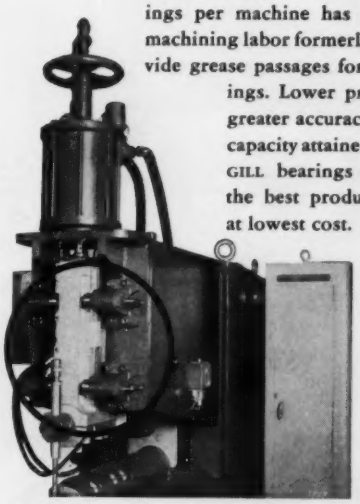
SCHIELD BANTAM UTILIZES CF BEARING ADVANTAGES IN VARIETY OF APPLICATIONS.

The Schield Bantam Company has applied CF bearings in internal clutch band operating arms, turn controls, swing and travel shaft clutch cones, engagement controls and speed shift collars. The photo above shows how CF-1 bearings are applied to Drum Clutches in Schield Bantam Series 350 cranes and shovels.

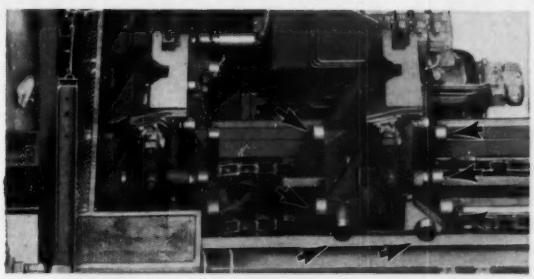
This company replaced bronze collars and yokes and reports cost savings through the use of CAMROL bearings. In addition they have increased capacity and have experienced improvement in length of life and maintenance factors. This has added to the over-all efficiency and dependability in heavy equipment where "down-time" is extremely expensive.

ACRO WELDER REDUCES PRODUCTION COSTS, IMPROVES ACCURACY WITH SCF BEARINGS

SEALED CAMROL bearings are used to accurately locate and guide the welding ram in spot welders made by ACRO WELDER MFG. CO. The user reports that the use of 12 prelubricated CAMROL bearings per machine has saved hours of machining labor formerly needed to provide grease passages for unsealed bearings. Lower production costs, greater accuracy and high load capacity attained with these McGILL bearings help to assure the best product performance at lowest cost.

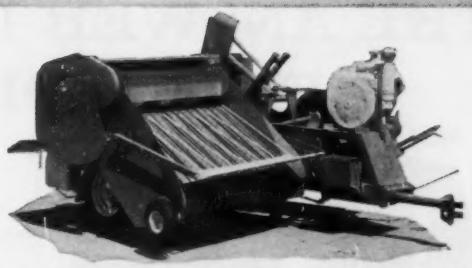


— insure precision performance in cam follower, track and guide roller applications



BUHR MACHINE TOOL CUTS FRICTION TO REDUCE HORSEPOWER WITH SEALED CAMROL BEARINGS

Production parts are drilled, milled, bored and tapped in automated systems engineered and built by the BUHR MACHINE TOOL COMPANY. The moving fixtures which hold parts being machined are guided and carried on McGill sealed CAMROL bearings as shown in the close-up above. By reducing starting and running friction to an absolute minimum, the CAMROL bearings have made horsepower requirement reductions possible in these systems. Ample load capacity, high resistance to shock loads and integral seals which retain lubricant and keep out contamination have held maintenance down. 8 SCF-3 CAMROL bearings guide and support each fixture.



J. I. CASE USES SCF AND SCYR CAMROL BEARINGS IN HAY BALER

The bale compressing plunger of the J. I. Case Model 177 Heavy Duty Hay Baler rolls on CF-2¾-S CAMROL Bearings and CYR-1¾-S Bearings guide the plunger.

Anti-friction bearing dependability and trouble-free performance are essential in this type of field equipment where bearing failure may result in loss of valuable harvesting time.

Integral bearing seals in these CAMROL bearings, keep relubrication requirements low and protect internal bearing components from field dirt, dust and moisture.

In addition to accurate, dependable action with minimum friction, high quality McGill CAMROL bearings offer savings on production and assembly.

engineered electrical products

McGILL®

precision needle roller bearings

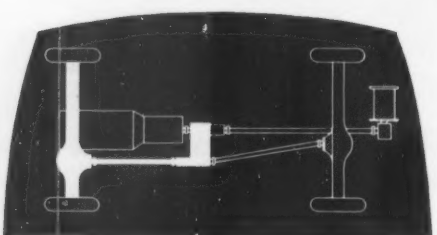
MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

Circle 449 on Page 19

When you need "pull" power as well as "push"...

THE ANSWER IS TIMKEN-DETROIT® FRONT DRIVING AXLES!

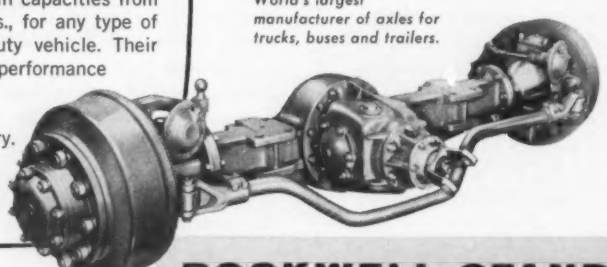


Rockwell-Standard produces front driving axles ranging in capacities from 4,800 lbs. to 20,000 lbs., for any type of medium and heavy-duty vehicle. Their record of outstanding performance on large off-highway fleets is unequalled throughout the industry.

There are many times when you need the extra power of front driving axles in rugged off-highway operations. And only the complete line of Timken-Detroit front driving axles and transfer cases best meets every requirement for these multi-wheel drive assemblies.

For more than 50 years, Rockwell-Standard has supplied components for multi-wheel drives. Rockwell's design, engineering and manufacturing experience—plus advanced research and testing facilities – assures highest quality. Use vehicles with multi-wheel drive for peak off-highway performance . . . *and specify Timken-Detroit!*

World's largest manufacturer of axles for trucks, buses and trailers.



Another Product of...

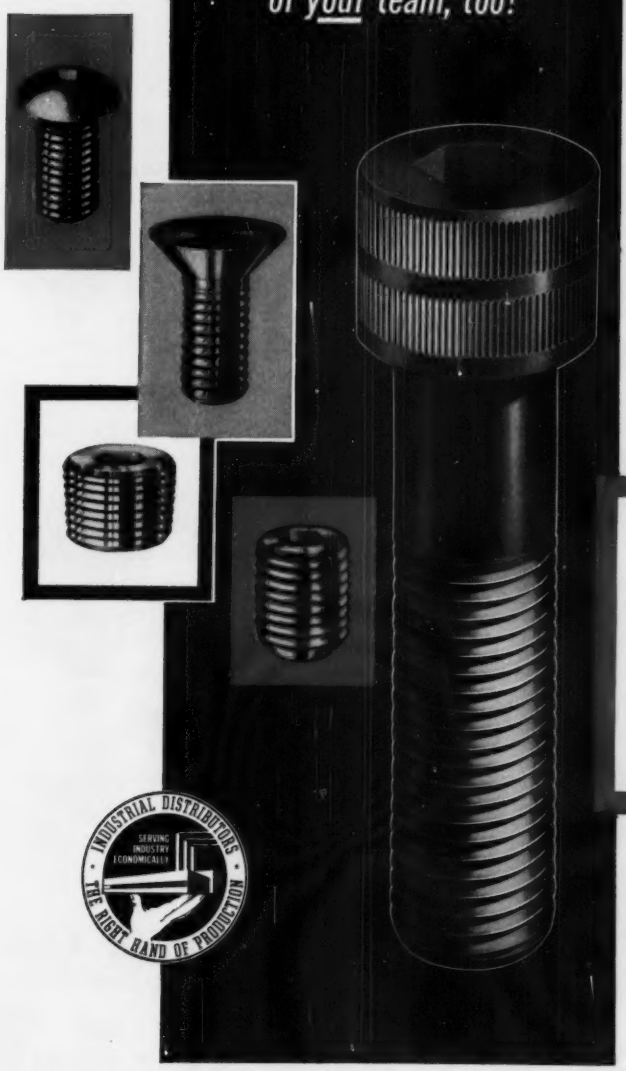
ROCKWELL-STANDARD CORPORATION

ROCKWELL R STANDARD ®

Transmission and Axle Division, Detroit 32, Michigan

INDUSTRIAL DISTRIBUTORS ARE PART OF THE H-K TEAM

. . . and important members of your team, too!

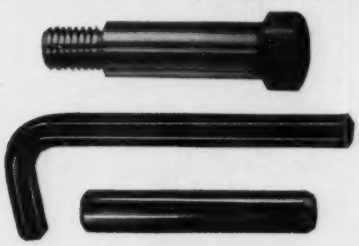


- Since the company was founded in 1929, Holo-Krome Forged Socket Screw Products have been sold only through authorized, stock-carrying industrial distributors. We believe this method of distribution is both economically sound and efficient. Distributors carry an adequate stock of H-K products right to the door of your plant; they provide on-the-spot engineering assistance; their knowledge of local problems means you get the products you want, when you want them, in the quantity you need.

- H-K's distributor team is as important as any department of our company. To back up our distributors, we are continuing to improve our product quality as well as our packaging, labeling, shipping, telegraph quoting service—and our unmatched SAME-DAY SERVICE on standard items.

- Know your Holo-Krome industrial distributor; call on him for assistance; rely on him for prompt service and technical help...

HE'S A RESPECTED MEMBER OF THE H-K TEAM!



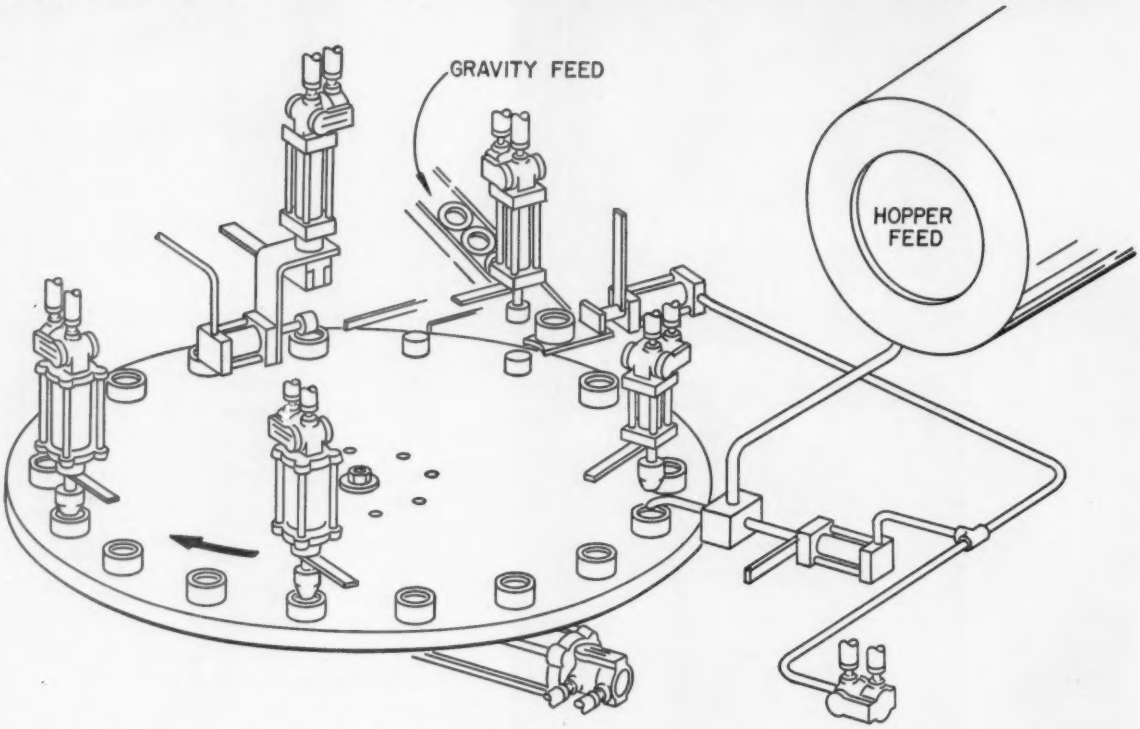
HOLO-KROME SOCKET SCREWS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

Sold only through Authorized Industrial Distributors

Circle 451 on Page 19

THIS BELLOWS "SPOT-A-MATION IDEA" SAVED $82,754.00

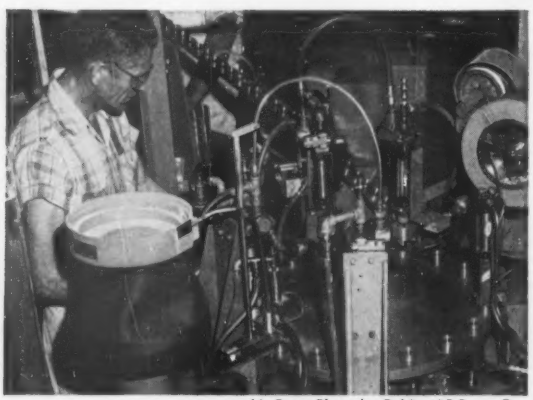


Engineers at the Naval Ordnance Plant, Macon, Georgia, were given the assignment to "effect major production economies" in the assembling of explosive components for ordnance use. The operations were being performed manually by 33 people. The engineers designed and built two automatic assembly machines, each using a Bellows Rotary Index Table and five explosion-proof Bellows Air Motors. The savings on direct labor costs alone on one contract amounted to .0109 man-hours per assembled part for a total dollar savings of $82,754.00.

This same basic idea can be readily adapted to handle an almost unlimited range of small parts assembly procedure: staking, crimping, screw or stud placement, welding partial or complete small assemblies, etc.

It is typical of the many ways ingenious engineers "spot-automate" costly and troublesome production centers with Bellows "Controlled-Air-Power" Devices.

Chances are that many such opportunities exist in your plant. Why not investigate today?



Air Force Photo by Robins AF Base, Ga.

The savings of $82,754.00 made through these automatic assembly units are based on direct labor costs and are exclusive of any possible savings from reduced overhead. In addition, 1000 sq. ft. of floor space was released for other operations.

THIS "SPOT-A-MATION IDEA" FILE IS YOURS ON REQUEST

Contains installation data, wiring diagrams and equipment lists for the assembly idea sketched above, as well as a score of other "Spot-a-mation" ideas you can use. Write Dept. MD-360. The Bellows Co., Akron 9, Ohio.

1492-B

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

The new LICON® line . . . precision switches for every need

In the new, broadened Licon line you'll find every switch designed to meet modern high capacity, long life requirements. These are switches built to do today's tough jobs. Typical is the unique Type 16—heart of many Licon switch assemblies—tiny in size but rugged enough to handle big switch loads with unbelievable life. Check the unusual "specs" of the Type 16, and all Licon types, against your switch needs—see and compare Licon life against any switch —we're sure you'll specify Licon.

Send for catalog on new broad **Licon** *line*

—Gives handy dimensional data and engineering specifications you'll want to keep for ready reference.

Type 30 Enclosed Limit Switches—Interchangeable components form up to 16 switch types for quick replacement. High quality, compact, low-priced. 15A., 125V a-c—for industrial applications.

H—Hermetically sealed Switches—Designed for dependability in extreme environments. Unique, true hermetic sealing against dust, moisture and other elements. Designed especially to your application.

Type 14 Heavy-duty Switch—Built for heavy industrial and machine tool service. Rugged snap-action has large contacts rated 20 amps at 250V a-c.

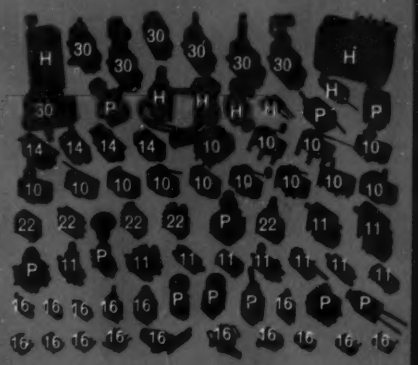
Type 10 Long-life Basic Switch—New Serpentine action mechanism delivers 10 million operations without failure. Can be provided with movement differentials as low as .0005". Rated 15 amps.

Type 22 Double-pole, Double-throw Switches—Provide positive control of four independent circuits. Simplifies controls for multiple circuit applications—withstands 25G at 2000 cps. Rated 15 amps., 125/250 V a-c, 30V d-c (res.).

P—Panel mounted Switches—Variety of types—to 8 or more poles—some solenoid reset or magnetically held—sealed and unsealed as required.

Type 11 Snap-action Switches—Resist 50G vibration to 2000 cps. Double-break, snap-action design eliminates dead break, contact welding and provides greater capacity. Rated 10 amps., 125/250V a-c, 30V d-c.

Type 16 Subminiature Switches—Here's big-switch performance in a tiny unit. Only ¼" thick, 25/32" long—yet rated 10 amps, 30V d-c ind. Greatest shock- and vibration-resistance of any switch in its class on the market . . . even near trip point.



Licon

Available through your local Licon distributor.

DIVISION OF ILLINOIS TOOL WORKS

6606 W. Dakin Street, Chicago 34, Illinois

Circle 453 on Page 19

ROLLWAY MAXIMUM BEARINGS

. . . . . What's the limit: Heat? Shock? Speed? Or complicated radial and thrust loads?

Name the combination of requirements . . . and chances are you'll find them met by a Rollway Maximum precision radial cylindrical roller bearing. If not, then Rollway engineers will modify any factor to meet your application.

Rollers are crowned to prevent end-loading and the resultant spalling of races. Directional trueness is maintained by retainers of standard bronze or "Rollube" ferrous alloy of one piece or two piece construction.

You may wish to refer to the Rollway Catalog and Engineering Data Book when writing specifications for a high precision bearing. It contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings. Send for it today.

ENGINEERING OFFICES:

Syracuse Boston Chicago Detroit
Toronto Pittsburgh Cleveland
Seattle Houston Philadelphia
Los Angeles San Francisco

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

Circle 454 on Page 19

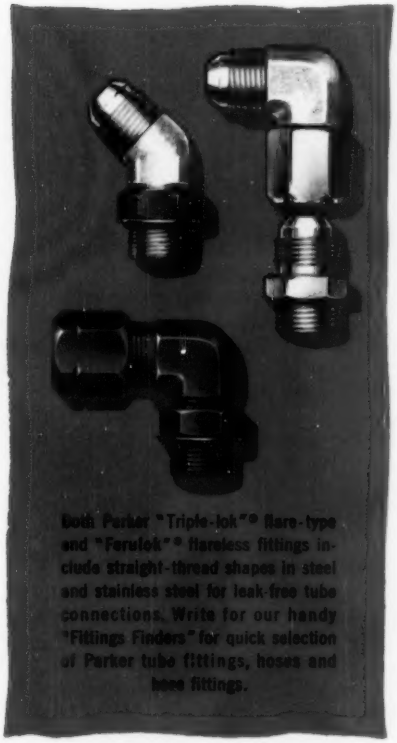
For Literature on Cylinders Circle 455 on Page 19→
For Literature on Fittings and Hose Circle 456 on Page 19→

Hannifin high-pressure hydraulic cylinders feature a drip-free rod gland with "LIPSEAL"® and "WIPERSEAL." This feature, plus straight-thread, O-ring-sealed ports, insures leak-proof cylinder installations.

Parker "Krimp-lok" permanent-end hose assemblies and "Hoze-lok"® reusable fittings can be ordered with O-ring-sealed straight threads to insure leak-proof hydraulic connections to 5,000 psi.

from **PARKER-HANNIFIN...**

straight-thread ports and fittings for leak-proof hydraulic systems



Both Parker "Triple-lok"® flare-type and "Ferulok"® flareless fittings include straight-thread shapes in steel and stainless steel for leak-free tube connections. Write for our handy "Fittings Finders" for quick selection of Parker tube fittings, hoses and hose fittings.

Parker straight-thread hydraulic fittings, mated with S.A.E. bosses (offered at *no extra charge* on Hannifin cylinders), guarantee leak-proof cylinder port connections.* This use-proved sealing method is J.I.C. recommended.

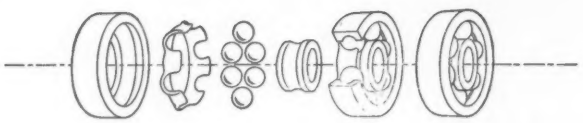
To insure leak-proof performance throughout your hydraulic systems, Parker offers both "Triple-lok" flare-type and "Ferulok" flareless fittings for leak-proof tube connections. Where you need high pressure, permanent-end hydraulic hose assemblies, Parker supplies "Krimp-lok." And for fast, leak-proof field service or replacement, Parker "Hoze-lok" fittings require no skiving of the hose, need a minimum of tools for assembly.

Your Parker-Hannifin man is qualified to help you with installation problems. He'll also help you plan your hydraulic layouts.

**Both Parker fittings and Hannifin cylinders are still available with "dry-seal" pipe threads.*

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

HANNIFIN COMPANY
545 S. Wolf Road, Des Plaines, Illinois



MEASURING ROUNDNESS OF INSTRUMENT BALL BEARINGS

By **RICHARD E. AMIDON**, *Staff Engineer, Production Engineering Department*
New Hampshire Ball Bearings, Inc.

Roundness of instrument ball bearings is a variable not covered by ABEC standards. Yet, it is an important factor in running quality. Since it is a very difficult variable to measure, except with costly equipment, most users must accept roundness on faith.

Roundness can be defined as "equidistance of all points on a curved surface from a fixed center". To measure roundness of a ball bearing component, therefore, you must establish its center and radius. However, since its center is not accessible as a point of reference, you must establish an "artificial" center. The closer the assumed or artificial center is to the actual center, the more accurate a given method of roundness measurement will be.

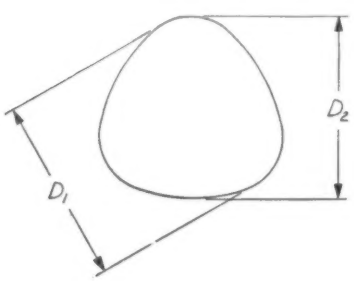
What you're really measuring is out-of-roundness, or deviation from a true circle. Such deviations are called lobing. There are three common ways of measuring out-of-roundness.

THE TWO-POINT METHOD

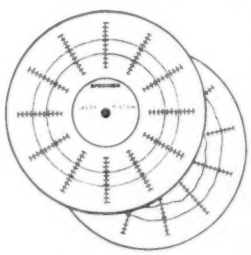
Most widely used of all measuring techniques is the method of measuring various diameters between two anvils as in a micrometer or two-point gage. The difference between the largest and smallest diameter is out-of-roundness. This method is accurate only if there is an even number of lobes of equal height and symmetrical spacing. Notice in the accompanying sketch of a three-lobed shape, all three diameters are equal . . . and the two-point method would indicate perfect roundness.

THE THREE-POINT METHOD

When an odd number of lobes exists, a three-point gage can be used to measure out-of-roundness. Variations are measured by rotating the part between two fixed points at a known angle with each other and a movable point connected to an indicator. This method, which calls for calculations to convert indicator readings to true-out-of-roundness, is accurate only when the number of lobes is known and they are symmetrically spaced and equal in height.



ELECTRONIC GAGING



POLAR CHART TRACE

Fortunately for you, instrumentation has been recently developed which measures out-of-roundness directly as radial variation with accuracy to several millionths of an inch. The part to be measured is chuck-mounted to a precision spindle and slowly rotated. An electronic gage head translates radial surface variations into a polar chart trace with deviations magnified as much as 10,000 times. Comparison of the chart trace with concentric circles of known radii reveals absolute deviation from a true circle. New Hampshire Ball Bearings, Inc. was the first to use this instrument as a quality control tool in the laboratory and on the production line. Other instrumentation used to assure the running quality of New Hampshire Bearings is described in our new Design and Purchasing Manual.

NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication covers everything you need to know about applying and buying miniature and instrument ball bearings. Comprehensive general information, catalog data and engineering bulletins are included in its 100-plus pages. Personally registered copies are available to qualified engineers, draftsmen and purchasing agents. Please send your request on your company letterhead.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

Circle 457 on Page 19

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You are cordially invited to visit us in our new factory — 242,000 sq. ft. of busy and well-organized manufacturing capacity.

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COLD-HEADED SPECIAL PARTS

Substantial savings are often available to manufacturers through the use of low-cost cold-headed parts in place of complex assemblies. Our sales engineers and field representatives are ready to give you skilled advice on possible applications in *your* products. *Call your Elco representative.*

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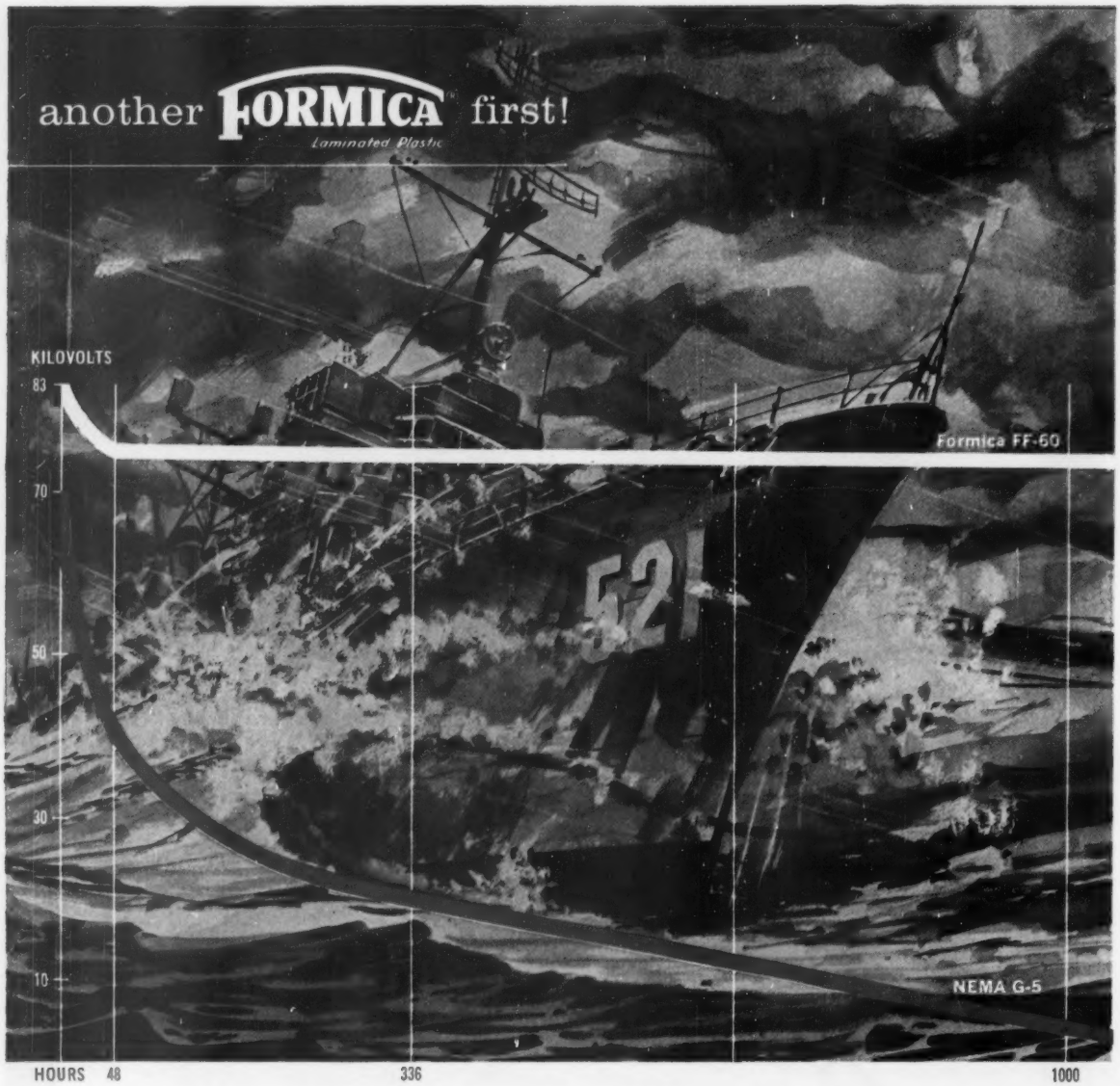


new FF-60 reduces moisture problem

FF-60 Electrical Properties

Dielectric strength (step by step) v/mil	
Cond. A	450
Cond. D48/50	400
Insulation resistance, C96/35/90, megohms	20,000

Formica FF-60, new glass melamine laminated plastic designed to meet the new Mil Specs for type GME, retains many times the dielectric strength of NEMA G-5 after prolonged exposure to moisture! It also offers superior craze resistance and excellent heat-, arc- and fire-resistance.

It is well suited for use in circuit breakers, switch bases, in shipboard power generation and distribution systems – and in similar military and commercial applications requiring the most dependable electrical insulation in moist conditions.

Test FF-60 yourself. Write for free sample and data sheet. Formica Corporation, a subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.

FIF

FF-60 parts *fabricated better, faster – 24 hours in some cases . . . by your local Fabricator of Industrial Formica laminated plastics . . . who also stocks FF-60 and other standard sheets for immediate delivery. Consult telephone directory, SWEET'S Product Design File, Thomas' Register or McRae's Blue Book for the FIF fabricator nearest you.*

FORMICA
Laminated Plastic

a product of CYANAMID

FI-2219

Circle 459 on Page 19

RB&W FASTENER BRIEFS

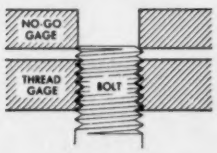
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

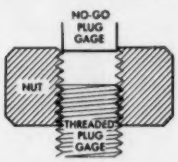
Proper inspection for screw threads

Thread inspection should answer two questions. (1) Will the threads allow easy *assembly?* (2) Is there sufficient thread depth for strength?



EXTERNAL THREADS

Strength requires sufficient thread flank engagement, which is checked by a *minimum* major diameter *plain* ring "no go" gage. Assembly is controlled by thread lead and maximum metal, which are checked by a *threaded* ring "go" gage.

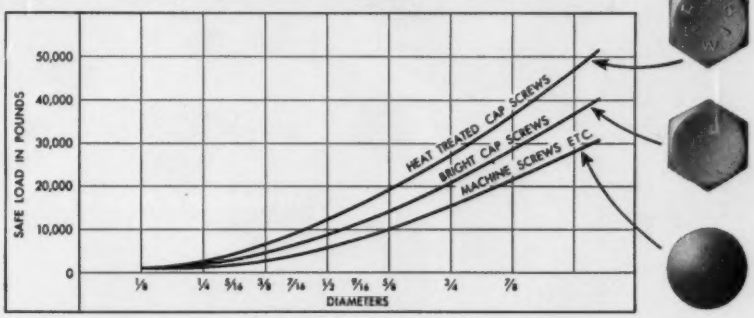


INTERNAL THREADS

The same reasoning holds true here. Use a threaded plug "go" gage to determine any interferences from thread lead or thread diameter that hinder ease of assembly. The unthreaded "no go" plug will assure proper thread depth for sufficient flank engagement.

Checking both thread lead and pitch diameter with two threaded "go" and "no go" gages not only increases inspection cost but also permits acceptance of pieces with insufficient thread metal.

How to simplify selection of fastener material



Safe loads for fasteners made from the three most common steel grades are shown on these curves. Curve for Grade 2 is smooth through the ⅞" size. There is no drop in proof load because RB&W fasteners up to 6" long are cold headed even in 1" diameters.

Basic job of a mechanical fastener is *physical.* It's designed to exert a clamping force.

Fasteners from a *standard* analysis of steel satisfy a majority of the usual requirements for this function. Most times, then, specifications should concern themselves solely with *physicals* for the job. Asking for certain chemical analyses to get the right physicals is doing it the hard way. It can create a needless cost penalty besides.

WIDE RANGE OF LOADS

Generally, the desired physicals can be delivered by a combination of cold working and heat treatment of one of the following common grades.

Grade 1 (or SAE 1010) steel goes into fasteners that offer a design load of 30,000 psi, such as carriage bolts and machine screws.

Grade 2 (or SAE 1018, 1020, 1021) steel goes into bright hex screws and similar items with a recommended design load of 40,000 psi in sizes up to ¾". SAE proof load then drops from 17,350 lbs. in ¾" size to 12,900 lbs. in ⅞" size *unless cold heading is specified!* This is because larger fasteners are often hot headed, resulting in some annealing. The strengthening effect of cold working is lost.

Grade 5 (SAE 1038) steel provides high strength heat treated bolts and hex screws with 60,000 to 80,000 psi design load range.

USE THE FULL INHERENT STRENGTH

When calculated load on a fastener is below those values, you're wasting its strength and cost. Using the smallest size fastener consistent with the load, and tightening to its maximum load actually increases joint strength.

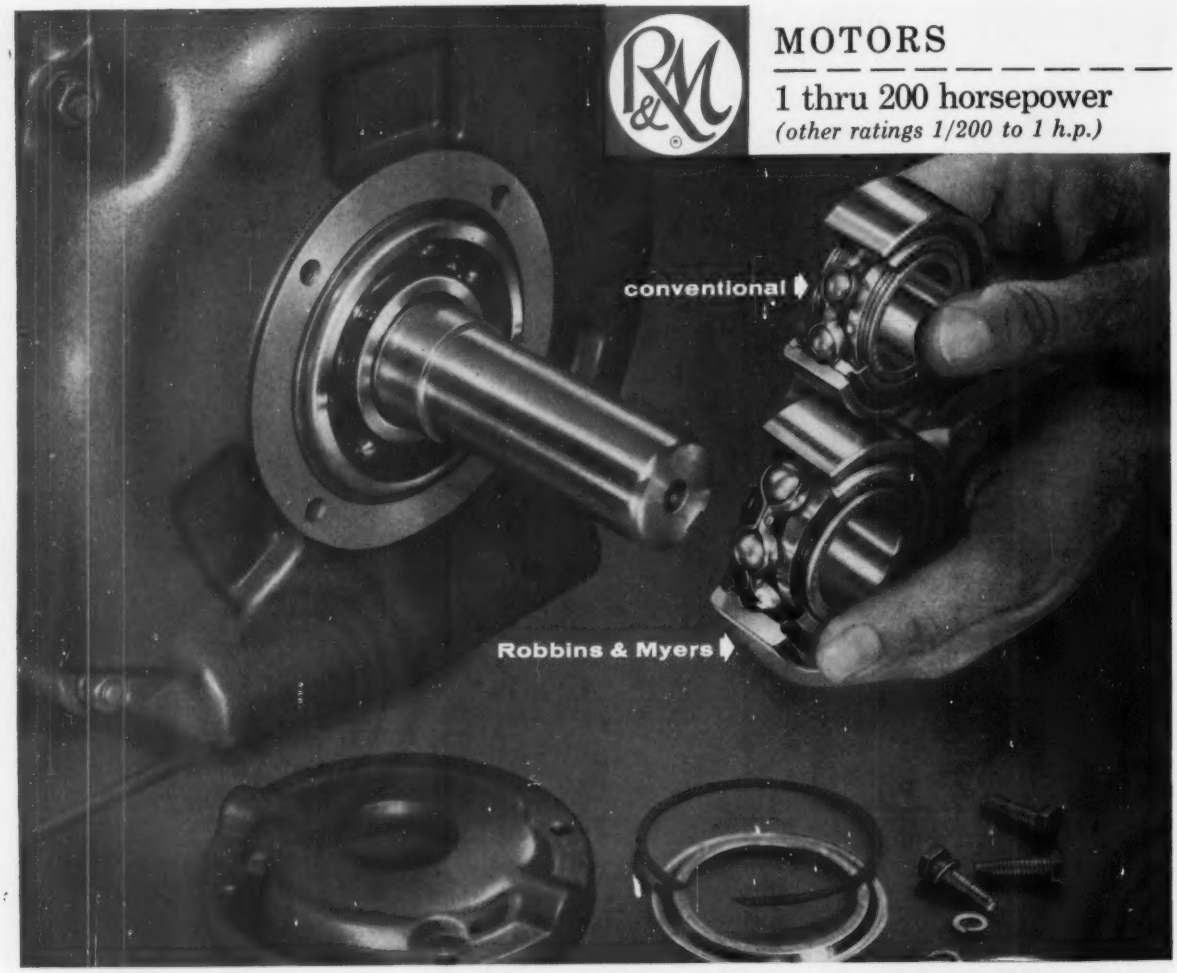
When you need an alloy steel because of space or weight or higher temperature or strength requirements, specifying physicals will automatically force your supplier to go to high alloy steel.

You will get what you need without selecting the exact alloy to be used. Just be sure you're served by a technically qualified and experienced fastener manufacturer.

Bulletin DC-2 gives other helpful hints. Send for it—or the RB&W Man. Russell, Burdsall, & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

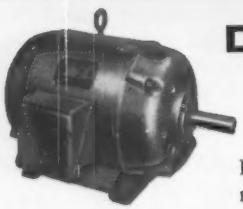
Circle 460 on Page 19



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

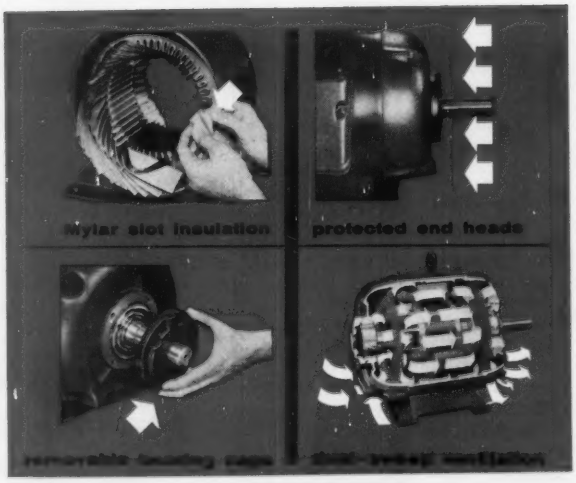


Double Width Bearings Hold More Grease...*Insure Longer Motor Life!*

Bearings in ROBBINS & MYERS motors run in double-width races with extra-large lubricant reservoirs. Bearings are fully sealed and pre-lubricated with laboratory tested grease which resists dust, temperature, humidity and high operating speeds. Tests prove these bearings can withstand six to nine years of severe service without relubrication. Bearings are further protected by metal seals on each side. Seals keep impurities out, prevent failure caused by "forgotten" lubrication or damaging over-lubrication.

R&M insures longer motor life with many additional features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling. For details, write today for Bulletin 520 MD

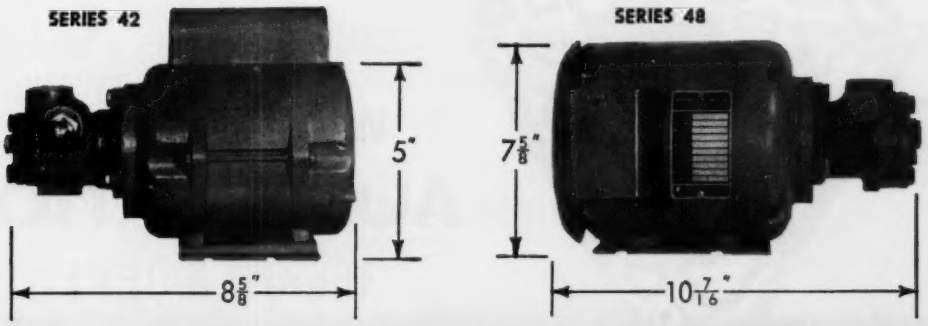
**DuPont registered trademark*



ROBBINS & MYERS, INC.

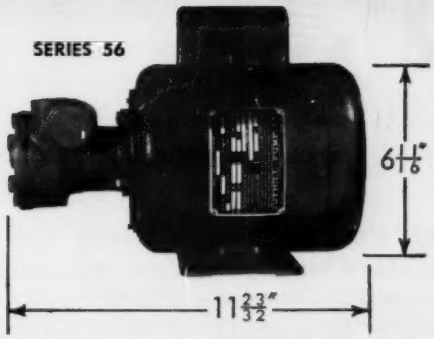
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO



SAVE SPACE...WEIGHT...MONEY

with TUTHILL close-coupled pump and motor combinations



Tuthill close-coupled pumps and motor combinations are especially designed for applications where space is at a premium. Their compactness simplifies assembly operations and lowers production costs. Elimination of couplings, bases and adapters results in significant savings . . . and reduced weight means lower shipping costs.

Tuthill offers a complete selection of units with capacities up to 50 GPM for pressures to 500 PSI. A wide variety of special options is also available. Three standard units are pictured above.

Immediately available from stock

The series 42 units measure only 5"x8 5/8". Their total enclosed ballbearing motors are normally supplied with ratings from 1/12 to 1/6 HP while the pump units have capacities of 20 to 45 GPH at 200 PSI.

Series 48 units, measuring 7 5/8"x10 7/16", are normally supplied with totally enclosed, fan-cooled motors of either split phase, capacitor, or 3 phase construction . . . with ratings from 1/4 to 1/2 HP. They can be supplied with pumps with capacities from 20 GPH to 360 GPH at 200 PSI.

Series 56 units measure 6 11/16"x11 23/32", and are offered in a complete range of motors varying from 1/4 to 1 HP. These can be coupled with pumps with capacities from 20 to 360 GPH at 200 PSI.

Although motors are normally furnished for 1725 RPM they are also available for 3450 and 1140 RPM. Explosion proof construction and double shaft extensions on motors are also furnished in series 48 & 56. Built-in relief valves are optional on all five pump sizes.

Special construction for OEM applications

The units shown plus others in Tuthill's line are immediately available without any quantity restrictions whatsoever.

For those original equipment applications involving substantial quantities, Tuthill's engineers can design and build a POWERMITE . . . an exclusive Tuthill design in which pump and motor are combined in one unit which takes up no more space and weighs no more than a standard electric motor. As an example of the compactness possible a Tuthill POWERMITE now being supplied for a hydraulic application measures only 4 3/4"x8 1/16", yet has a capacity of 16 GPH at 350 PSI.

Tuthill's field engineers will be happy to provide details on the complete Tuthill close-coupled line and its application to your particular problem. If you are trying to fit a pump and a motor into a tight space you should talk to them soon. Call today.

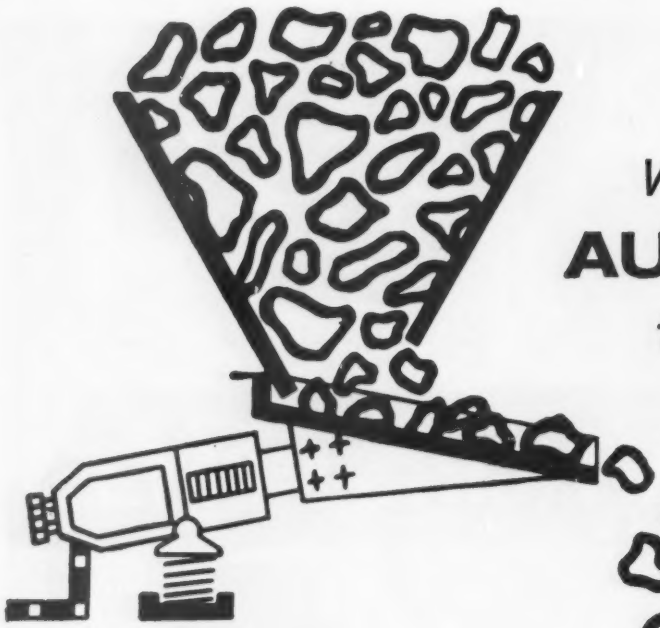
Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressure to 300 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

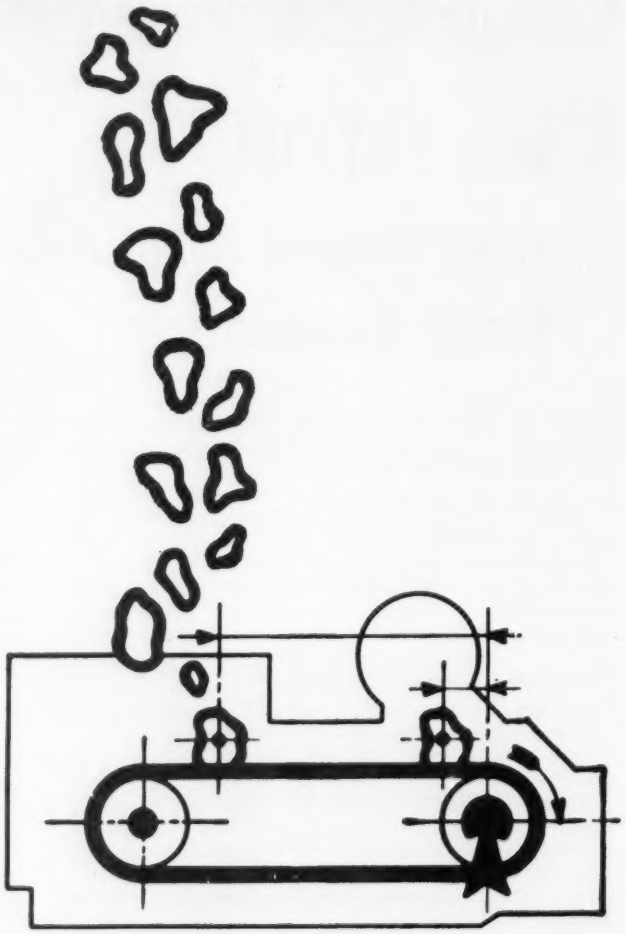
Circle 462 on Page 19



When you're planning

AUTOMATION...

there's a JEFFREY feeder to control material flow



JEFFREY ELECTRIC VIBRATING FEEDERS are capable of handling most classes of materials and of meeting all flow requirements—a few pounds or many tons per hour. Feeders can be operated on the level, up- or down-grade, and rate of feed can be changed at will while the unit is running. Various styles of decks can be furnished, to suit materials handled and operating conditions.

Many manufacturers include Jeffrey vibrating feeders to maintain a flow of materials into and away from the machinery they are building.

JEFFREY WAYTROL® CONSTANT WEIGHT FEEDERS are often designed into a system where bulk materials must be fed to a process at a definite rate, or where proportioning is handled automatically. The Jeffrey Waytrol is an accurate, rugged unit for weight-metering materials. Separate feeding components are supplied to meet individual requirements; vibrating feeders, spiral or belt conveyors.

Waytrols range in capacities from 60 pounds per hour to 750 tons per hour. Tell us the capacity you need, the character of the material you plan to handle, and Jeffrey engineers will recommend the feeding layout you need.

For Catalog 941 describing Jeffrey equipment for the process industry, write The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT
...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

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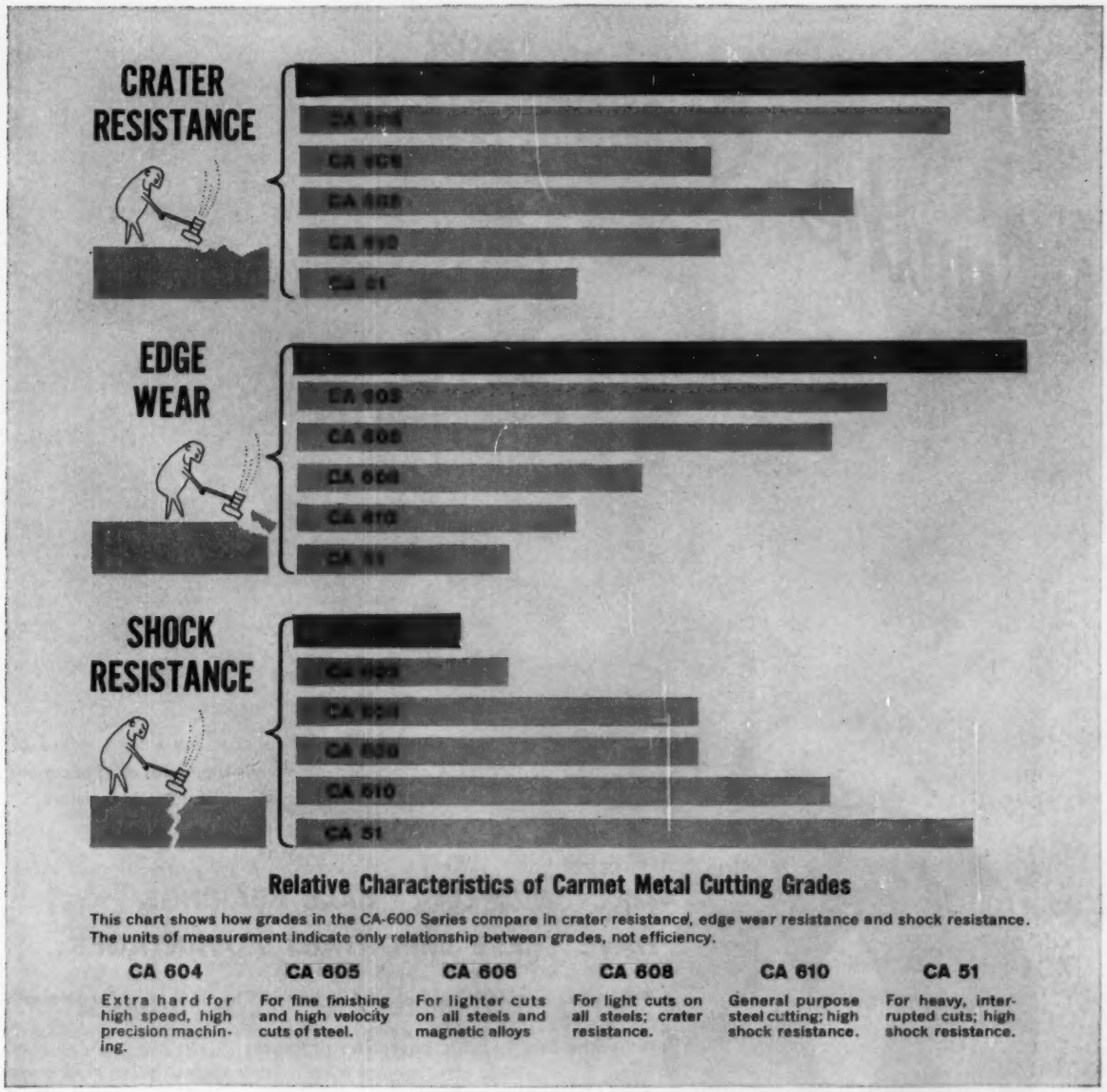


Relative Characteristics of Carmet Metal Cutting Grades

This chart shows how grades in the CA-600 Series compare in crater resistance, edge wear resistance and shock resistance. The units of measurement indicate only relationship between grades, not efficiency.

CA 604	CA 605	CA 606	CA 608	CA 610	CA 51
Extra hard for high speed, high precision machining.	For fine finishing and high velocity cuts of steel.	For lighter cuts on all steels and magnetic alloys	For light cuts on all steels; crater resistance.	General purpose steel cutting; high shock resistance.	For heavy, interrupted cuts; high shock resistance.

HERE'S THE QUICK STORY ON THE NEW CARMET® CA604

Super-hard cemented carbide designed for today's high-speed, high-precision machining of steel

Product of Allegheny Ludlum research, CA604 is now added to Carmet's crater-resistant 600 series. It is an ultra-hard tungsten carbide with unusually high crater-resistance, wear life and high strength at elevated cutting temperatures. CA604 is an outstanding performer in the fast cutting ceramic areas, combining high velocity finishing with light to medium feeds.

CA604 is offered in Indexable Inserts and Blanks by your Carmet distributor. He carries Carmet standard tools, holders and Indexable Inserts in stock and assures prompt delivery. Call him for help in selecting the proper grades and styles for economical machining—or write *Allegheny Ludlum Steel Corporation, Carmet Division, Detroit 20, Michigan.*

215

Write for New-Revised CATALOG C-16-S
CARMET CEMENTED CARBIDES FOR INDUSTRY

This 32-page book contains revised prices and complete specifications on Carmet's full line of cemented carbide tipped tools, blanks and holders. Speed and feed charts, grade comparisons and ordering information included.

ADDRESS DEPT. MD-27

CARMET

CEMENTED CARBIDE DIVISION OF
ALLEGHENY LUDLUM STEEL CORPORATION

Circle 464 on Page 19

IN *Synthe-Seal*® BEARINGS

MARLIN-ROCKWELL

RELIABILITY

COUNTS

MRC Synthe-Seal® bearings have a long record of satisfactory performance in thousands of applications including extreme conditions of dirt and moisture.

MRC *Synthe-Seal*® BALL BEARINGS HAVE THESE IMPORTANT ADVANTAGES:

- Flexible synthetic rubber seal is bonded to steel core for strength
- Synthe-Seal® resists operating pressures
- Seal drag is controlled to give low torque with less power required
- Produce economy by eliminating maintenance time
- Reliability provided by elimination of down time
- Operating range from — 80° F. to + 225° F.
- Manufactured to standard AFBMA dimensions and tolerances
- MRC Synthe-Seal® bearings are backed by 62 years experience in manufacturing ball bearings

Send for FORM 1528 listing sizes available

Marlin-Rockwell Corporation

Jamestown, N. Y.

MRC BALL AND ROLLER *bearings*

Circle 465 on Page 19

Greater Corrosion Resistance

Longer Fatigue Life

Less Product Incrustation

new tests prove

CONTOUR-WELDED* STAINLESS TUBING

provides all three!

A recent series of tests prove TRENTWELD® tubing, made by the exclusive *Contour-Weld* process, is smoother than any other full-finished tubing. And still other tests show this extra smoothness ensures longer fatigue life, greater resistance to corrosion and less product incrustation.

But here's why *Contour-welded* tubing is smoother inside:

First, it's smoother than seamless because it's formed from uniformly rolled strip steel, whereas seamless must be extruded or pierced.

And second, it's smoother than other welded tubing because the Trent-patented *Contour-Weld* process virtually eliminates the weld bead.

But why not get full details on *Contour welded* tubing's superiority? Send for the free 48-page "Trent Weld Manual." It's chock-full of details on *Contour-welded* tubing in sizes from ⅛" to 40" — in stainless and high alloy steels, titanium, zirconium, zircaloy and Hastelloy†. Write: Trent Tube Company, Box 2518, Pittsburgh, Pa.

†Trademark Haynes Stellite Co.

In Conventional Welding

With Contour Welding

In **CONVENTIONAL WELDING** of tubes, gravity pulls molten metal down to form a bead that is difficult to remove by cold working. And cold working may lead to undercuts, focal points for fatigue cracks and corrosive attacks. Cleaning becomes difficult.

* With **CONTOUR WELDING** the tube is welded at the bottom. Gravity still pulls the molten metal down inside the tube, but now the weld area corresponds to the contour of the tube. There's virtually no weld bulge on the inside surface. And even on the O.D., the weld seam more closely conforms to the contour of the tubing.

CONTOUR TRENTWELD

stainless and high alloy pipe and tubing

TRENT TUBE COMPANY

Subsidiary of Crucible Steel Company of America • GENERAL OFFICES: East Troy, Wisc. • MILLS: East Troy, Wisc.; Fullerton, Calif.

Developing a motor-driven product?

Here's a Way to Make Sure You Get the Right Motor

When you reach the point in the development of a new product where you are ready to discuss the motor, we shall welcome an opportunity to carefully study your motor problem and try to find an existing motor design that will do the job.

If the *right* motor is readily and economically available, we shall tell you. Our interest is in devoting engineering man-hours to the solution of design problems—not in duplicating development work which already has been done.

Because of this approach and because of our motor design and development experience—44 years in the small motor field—we can help your company obtain the *right* motor . . . at the most favorable cost.

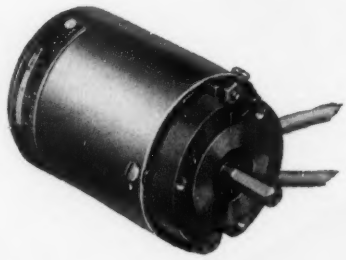
THE LAMB ELECTRIC COMPANY • KENT, OHIO

A Division of American Machine and Metals, Inc.

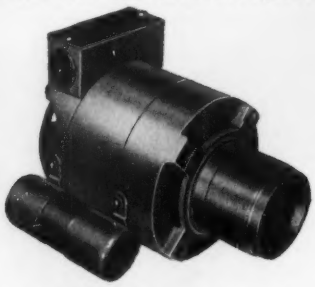
In Canada: Lamb Electric • Division of Sangamo Company Ltd. • Leaside, Ontario

Lamb Electric

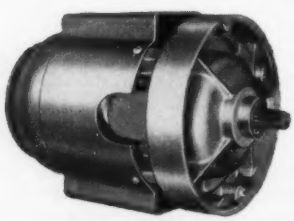
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**



Lamb® six-pole 400 cycle AC motor for electronic cooling in missile control equipment. Frame 1 11/16 x 1¼.

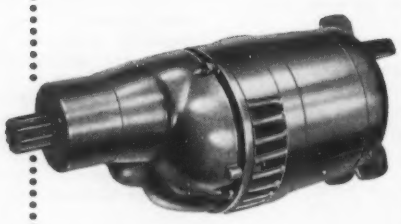


Lamb® four-pole capacitor start induction run motor with special bracket for telephone toll ticket process machine. Frame 4½ x 2¼.

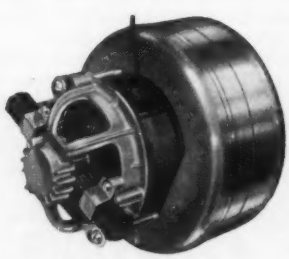


Lamb® totally enclosed fan-cooled explosion-proof motor for high pressure grease gun. Frame 3 1/16 x 2¼.

Write for your copy... 8-page folder describes these and other Lamb Electric motors.

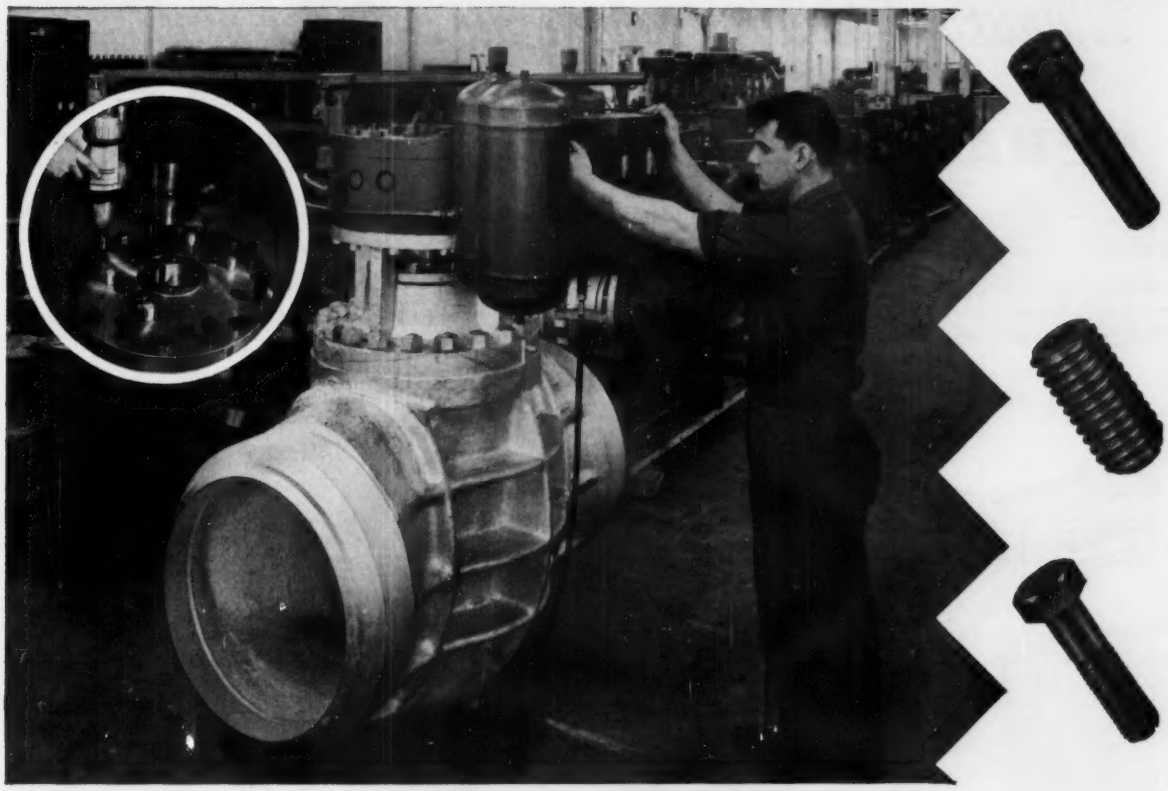


Lamb® heavy duty three-stage gearmotor for pipe threaders. Frame 4⅜ x 2¼.



Lamb® series motor with two-stage fan—the standard for high performance domestic canister-type cleaners.

IT PAYS TO STANDARDIZE ON **STANSCREW**



Stanscrew service adds strength, lowers costs for Shafer Valve Company

The valve operators produced by Shafer Valve Company of Mansfield, Ohio are used to open and close large valves on gas pipe lines . . . often in remote locations, many miles from human supervision. They are subject to sudden surge loads which cause extremely high stresses . . . and their critical importance demands unfailing reliability of all components.

Shafer formerly manufactured their own fasteners for this demanding application from a special high strength steel. Then their distributor arranged for a visit from Stanscrew's fastener specialist. He quickly established that Stanscrew's heat-treated "Carbon Restoration" cap screws, correctly applied, could provide even greater fastener strength . . . and at a significant saving in cost.

The Stanscrew fastener specialist may be able to make similar savings or improvements in your assembly operations. For he brings to your application the experience and facilities which have made Stanscrew a leading supplier of fasteners to the top names in American industry for over 80 years. And he can select money-saving answers to your problems from a complete line of over 5,000 different types and sizes of standard fasteners . . . always in stock, quickly available.

Whatever your fastener requirements, call your nearby Stanscrew distributor today. He will arrange for a prompt visit from the Stanscrew fastener specialist.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 468 on Page 19

...unusual features solve your cylinder problems

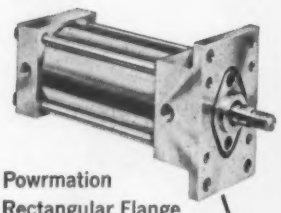
NEW HANNA *Powrmation* SERIES 1000 CYLINDERS

Pressure Safe Tube Seals

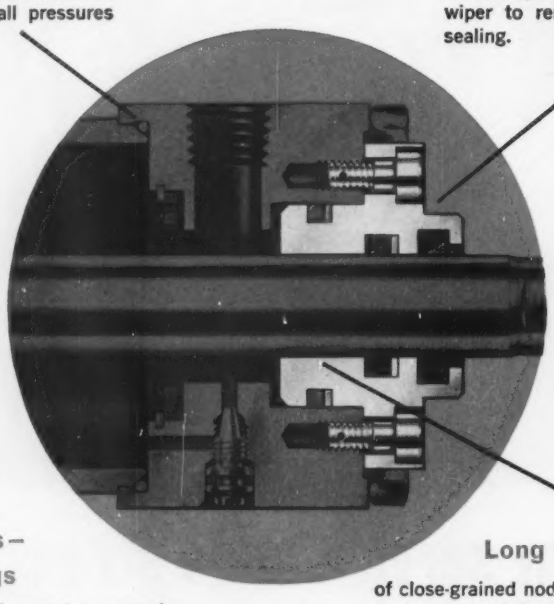
on the outside diameter of the tube create the most positive seal possible at all pressures from zero to maximum.

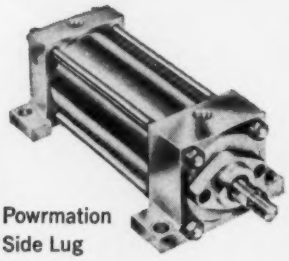
Fast Change Cartridge Gland

has leak-proof, low-friction rod seal and a rod wiper to remove dirt and to provide extra sealing.



Powrmation Rectangular Flange Rod End





Powrmation Side Lug Mounting

One Piece Steel Heads–Welded Steel Mountings

for maximum strength, perfect alignment . . . superior to bolted assembly. Mountings carry maximum cylinder load with ample safety margin.

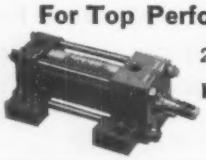
Long Lubricated Bearing

of close-grained nodular iron with high graphitic content . . . one of the finest bearing materials. Rod seal on external side of bearing provides automatic bearing lubrication by hydraulic fluid or airborne lubricant.

POWRMATION CYLINDERS FOR AIR TO 250 PSI • HYDRAULIC TO 1000 PSI • BORES: 1½" THROUGH 14"

All good cylinders have "features" but few have a combination of really *Unusual* features that assure superior cylinder performance and dependability . . . New Hanna Powrmation Cylinders have. The features shown above and several others like: Unique, Check-Valve Cushions; Low Friction Nodular Iron Pistons; Positive Seal Block Vee Packings; Chrome Plated High Strength Steel Rod;—all these together with Hanna precision manufacturing and Hanna Field Engineering Service are the reasons why it will pay you to specify Powrmation Cylinders . . . they meet J.I.C. recommendations and have dimensional interchangeability.

For Top Performance in Hydraulic Pressures

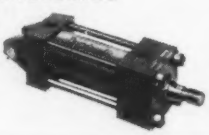


2000 PSI/3000 PSI Non Shock

HANNA POWRDRAULIC

Series 2000 CYLINDERS

Bores 1½" thru 8"



Write for Catalog 1000

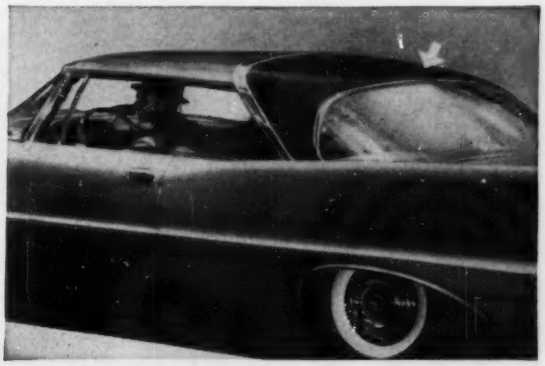
or ask Your Hanna Representative—see the Yellow Pages or Sweet's Design Catalog for his name

HANNA ENGINEERING WORKS

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue • Chicago 22, Illinois

1 Vinyl latex gives do-it-yourself paints greater:
(a) scrub resistance *(b) one-coat hiding power*
(c) freedom from lapping and streaking



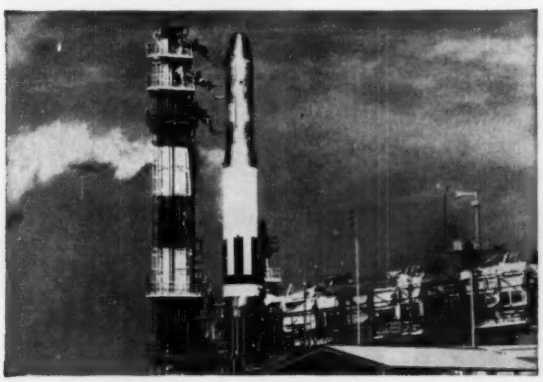
2 Rich, leather-textured finish on this auto top is:
(a) baked vinyl coating on steel *(b) vinyl coating on cloth*
(c) molded vinyl sheeting

Can you pass this test on Vinyl plastics?

(You'll discover more of their potential as design materials)

3 What parts of her shoes are molded vinyl?
(a) the soles *(b) the heels*
(c) the whole shoe

4 Well-dressed lambs wear vinyl film to:
(a) make them easy to find *(b) keep oil off shepherd's hands*
(c) protect against rain and cold



5 Chief advantage of vinyl jacket for missile control cable is:
(a) light weight *(b) flexibility*
(c) resistance to oxidation

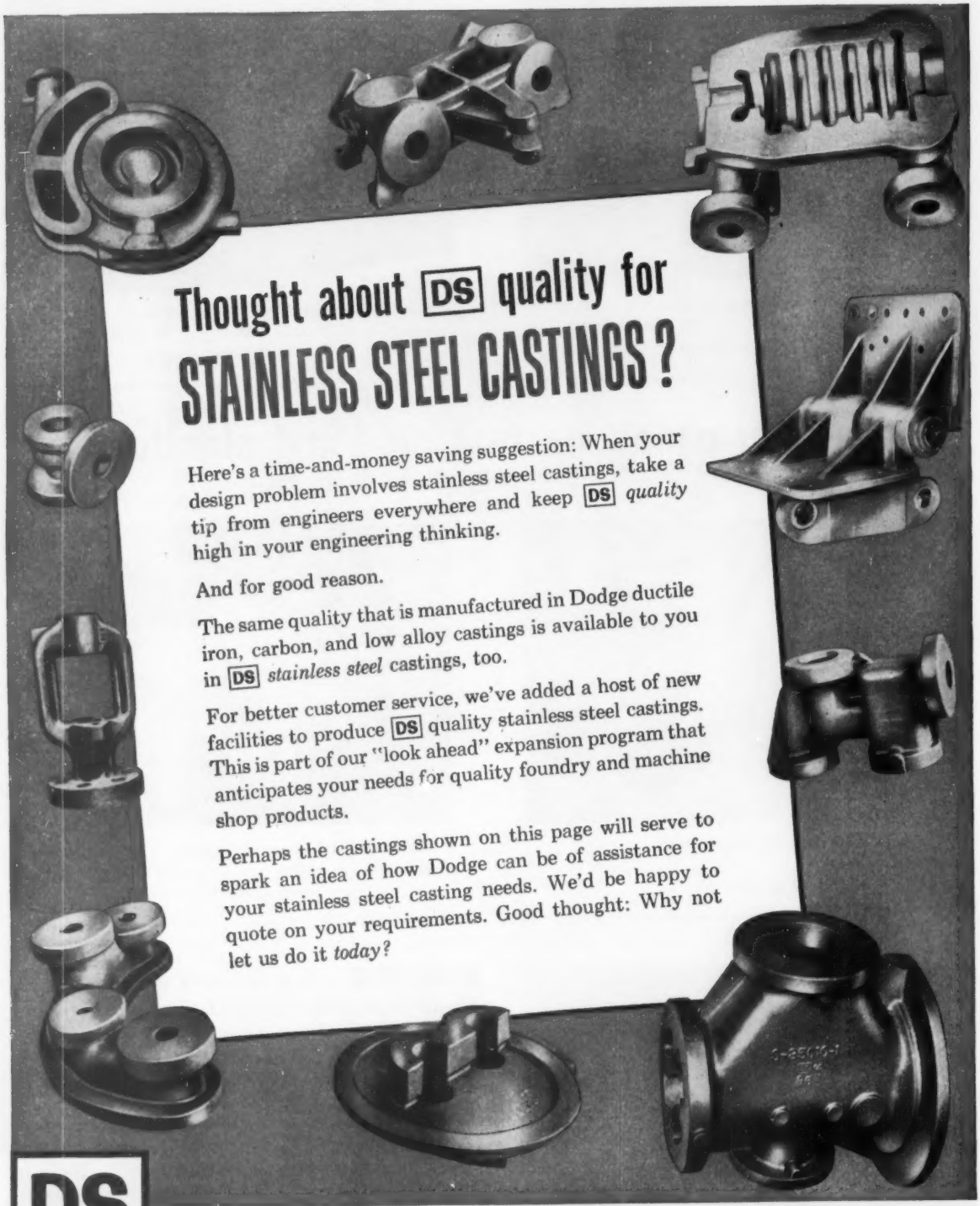
ANSWERS... *to a multitude of needs are found in versatile BAKELITE vinyl plastics:*

1: (a), (b), and (c). You're right if you picked them all.
2. (a) Textured vinyl coating on steel looks like leather—wears like iron.
3. (c) The whole shoe—waterproof, tough, glossy and scuff-resistant.
4. (c) Protection against weather—cuts drastic winter lamb mortality.
5. (c) Resistance to oxidizing effect of rocket fuel vapors. Light weight and flexibility contribute to ease of handling.

If you have questions—about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept CW-01D, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 7.

UNION CARBIDE

"Bakelite" and "Union Carbide" are registered trade marks of Union Carbide Corporation.



Thought about DS quality for STAINLESS STEEL CASTINGS?

Here's a time-and-money saving suggestion: When your design problem involves stainless steel castings, take a tip from engineers everywhere and keep DS *quality* high in your engineering thinking.

And for good reason.

The same quality that is manufactured in Dodge ductile iron, carbon, and low alloy castings is available to you in DS *stainless steel* castings, too.

For better customer service, we've added a host of new facilities to produce DS quality stainless steel castings. This is part of our "look ahead" expansion program that anticipates your needs for quality foundry and machine shop products.

Perhaps the castings shown on this page will serve to spark an idea of how Dodge can be of assistance for your stainless steel casting needs. We'd be happy to quote on your requirements. Good thought: Why not let us do it *today*?

DS

DODGE PRODUCTS

DODGE STEEL COMPANY

6501 State Road • **Philadelphia 35, Pa.** • DEvonshire 2-2200

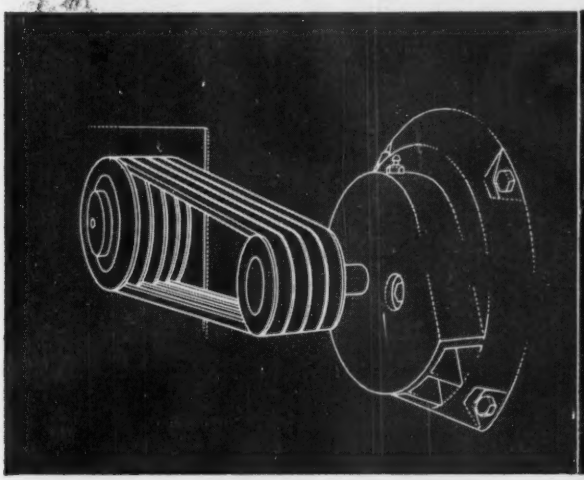
Stainless

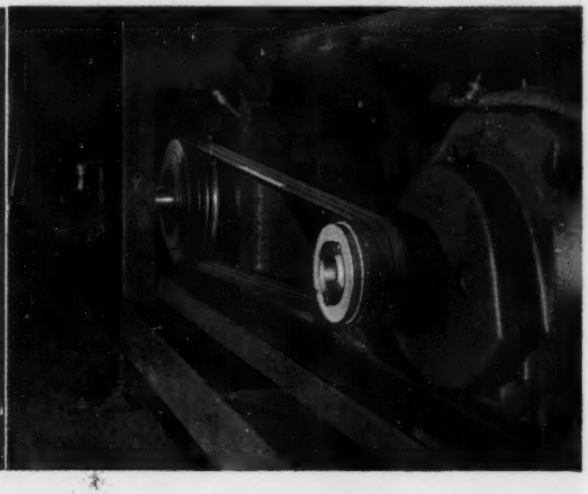
THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

Circle 471 on Page 19

BEFORE: This drawing of the former 4-belt drive on a clothes pressing unit is in the same scale as the photo of new Super HC V-Belt Drive at right. Heavy sheaves needed for 4 belts imposed high bearing loads.

AFTER: By redesigning the drive for Gates Super HC V-Belts only 3 belts are required and this Utah manufacturer saves 16 pounds in weight and 24% on the drive cost of every pressing unit it makes.





Manufacturer of pressing equipment cuts cost of drives 24%

New high capacity V-belt also saves weight and space!

This manufacturer is just one of many who have already turned to Gates Super HC V-Belts to achieve far more compact, lighter weight, lower cost V-belt drives for all types of machines. With new Super HC V-Belts, sheave dimensions can be reduced 30% to 50%, overall space up to 50%, and drive weight by 20% and more.

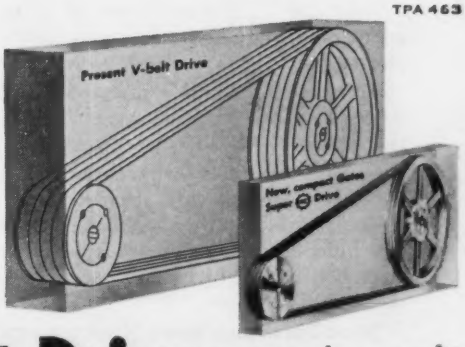
A product of Specialized Research in the world's largest V-belt laboratories at Gates, the Super HC V-Belt Drive is already standard equipment on production models in virtually every industry.

Engineering Service Nation-Wide

Whatever your plant's power transmission design problem, wherever you are, your nearby Gates Distributor or Field Representative is ready to assist you to cut space, weight, and costs with Super HC. Ask him for a copy of *"The Modern Way to Design Multiple V-Belt Drives."*

TPA 463

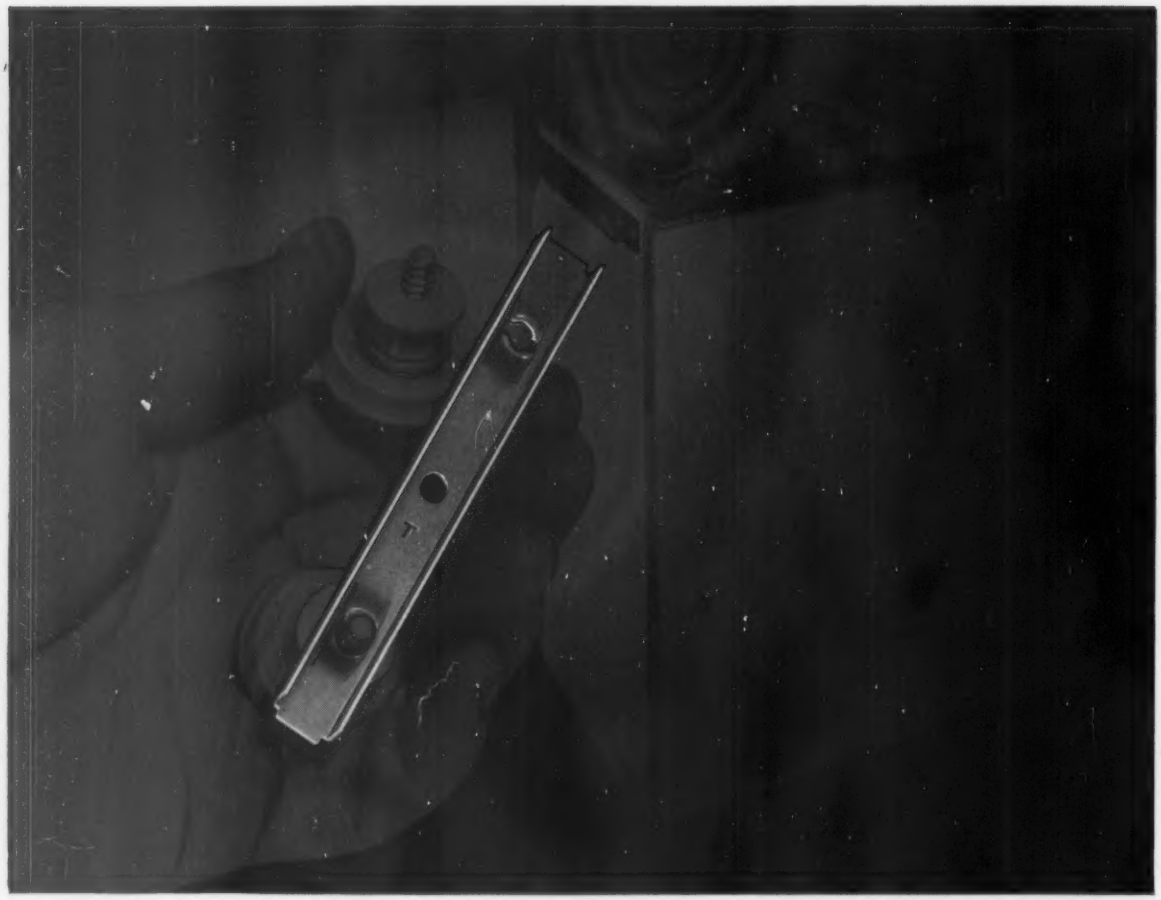
The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario



Gates *World's Largest Maker of V-Belts*

Gates Super HC V-Belt Drives

same hp capacity in smaller "package"



Engineered by Tinnerman...

Savings pyramided 68% by a switch to TINNERMAN SPEED NUTS®

First, the saving in material on the General Electric Dishwasher . . . a Tinnerman SPEED NUT brand fastener is formed right in a channel stamped from high-carbon spring steel. This replaces a costly solid steel bar formerly used to mount the pull-out basket rollers.

Next, the Tinnerman SPEED NUT impressions are stamped right in the channel; expensive boring and tapping of the bar stock are eliminated.

Third, sheet metal screws hold tight in the SPEED NUT, and are easier to start and drive than the machine screws formerly used.

General Electric's dishwasher production goes faster and assembly costs are reduced by the easy-to-apply feature of the simplified SPEED NUT part. The difference in weight even makes an important reduction in freight costs on each carload shipment of dishwashers.

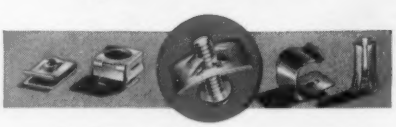
What Tinnerman SPEED NUTS accomplished for General Electric can probably be done for you.

A call to your Tinnerman Sales Representative will be the start. He's in the Yellow Pages under "Fasteners".

Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

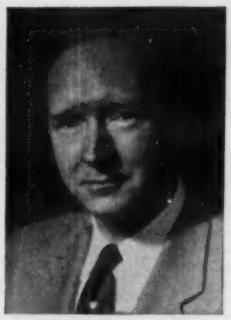
TINNERMAN
Speed Nuts®



FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Nacano-Bundy GmbH, Heidelberg.

MACHINE DESIGN
March 3, 1960



Qualified to Design

EVERY engineer aspiring to full membership of a top-ranking engineering society is expected to show that he is qualified to design. This is tantamount to saying that engineering *is* design.

Despite this, engineering colleges for many years offered little that could really be called education for design. Mechanical engineering curricula, for example, emphasized analysis and the single-answer problem, and offered training in calculation techniques of a few specialties, notably boilers and turbines.

Even the traditional machine-design courses provided little more than a review and extension of mechanics and strength of materials, with some practice in routine calculations for various standard machine elements. The design concept was covered by transposing the analytical formulas so that the answers were dimensions instead of stresses.

This sort of thing, coupled with unhappy experiences in freshman drawing, gave many competent students a false notion of design. They stayed away in droves from any job that smacked of "the board." The challenge of creative design was never presented to many young engineers.

Something like a revolution is now taking place in the colleges. The old-style design course is recognized as outdated and inadequate for today's and tomorrow's needs. Leading colleges are actively seeking a better answer.

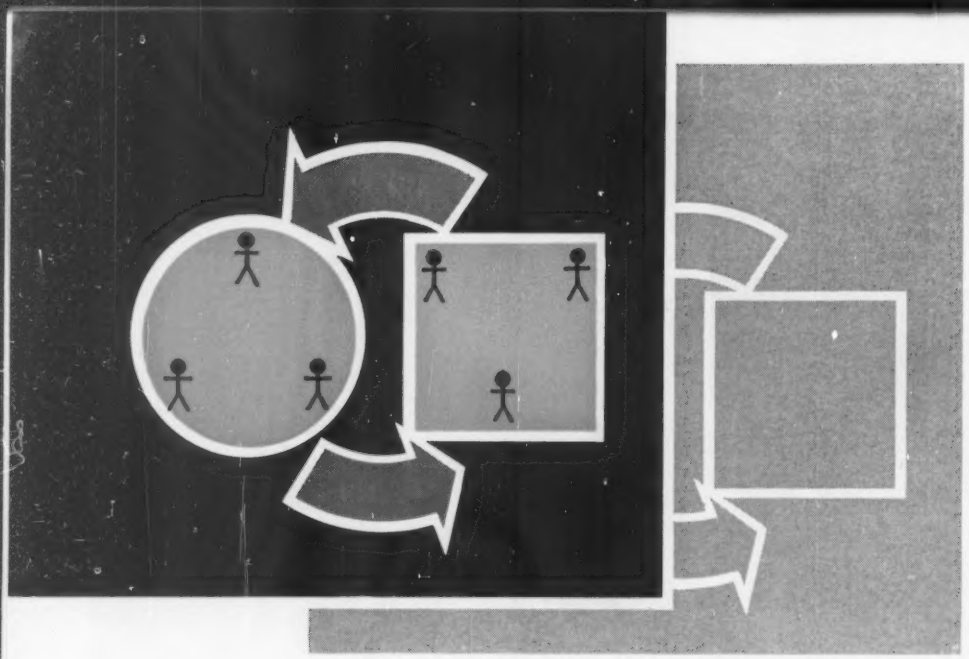
Design engineering, it is realized, is essentially a decision-making activity, not an exercise in applied mathematics. The problem is how to introduce such a radical notion into a curriculum largely built on single-answer mathematical solutions.

As a working design engineer, or as a manager of design engineers, you can help the educators develop the kind of engineer you would want to hire. Your experience tells you what was helpful in your own education, and what was valueless in developing design competence. Tell your acquaintances in the academic world, or write to the engineering dean of your own alma mater.

Write to us if you like. How would you go about developing men qualified to design — even beyond the frontiers of knowledge, where established routines fall down and there are few guideposts?

Colin Carmichael

EDITOR



As big projects change from conception to completion, project requirements change correspondingly. Here's how to meet these requirements with a . . .

Convertible Engineering Organization

GEORGE FRIED
Corporate Engineering Staff
American Machine & Foundry Co.
Stamford, Conn.

AS engineering projects proceed toward completion, they pass through recognizable stages of development. Each stage requires a distinctive organization for maximum efficiency and minimum friction. An impasse usually occurs because a fixed organization must be matched to a fluid activity. To resolve the problem, this article describes a type of engineering organization which is adjustable in both size and structure. Initial considerations are the identification of project stages and the examination of basic types of organization.

Stages of Development

In general, an engineering development project passes through three recognizable stages:

1. **Concept Stage:** This initial phase consists of familiarization with the project, its performance requirements and specifications, their evaluation, and the establishment of initial concepts. It also includes selection of principles to use for developing the device or system and for proving the technical feasi-

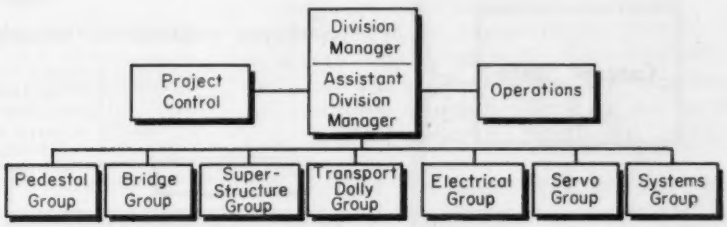


Fig. 1—Project organization.

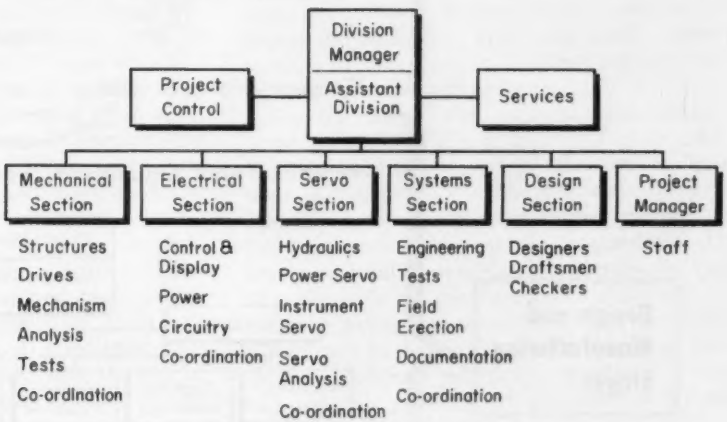


Fig. 2—Functional organization.

bility of the schemes involved.

The concept stage requires a relatively small crew of high caliber engineers. "General practitioners" are the best suited at this stage. Specialists are called in as required. Formal paperwork and rigid controls should be held to a minimum. Free brainstorming within well-defined bounds should be encouraged.

2. Design and Manufacturing Stage: This intermediate phase consists of the incorporation of principles established during the concept stage into a practical design which will meet project specifications. It also includes preparation of manufacturing drawings, fabrication of parts, and assembly of the whole system.

This stage requires a large number of people specialized in various fields of engineering. Co-ordination is of the utmost importance. Interface problems must be resolved impartially and quickly. Close follow-up with manufacturing groups is essential.

3. Testing and Completion Stage: This final phase consists of all necessary testing of components, subassemblies, and the entire system to determine whether they meet initial specifications. It also includes modifications, before and after delivery to the customer, to correct errors or improve the system on the basis of test findings.

This stage requires a small crew familiar with the over-all aspects of the job and working under strong leadership. Specialized knowledge, however, may have to be called in as required.

Functional vs. Project Organization

The several stages in the development of projects impose different requirements upon organizational structure. To meet these requirements, consider two major types of organization: Project and functional.

Project Organization: This type retains engineers of general knowledge. Assignments are made, not on the basis of specialties, but along logical lines of separation in the project itself. Some highly specialized functions, however, may have to be sepa-

Life Cycle of a Big Project

Concept Stage

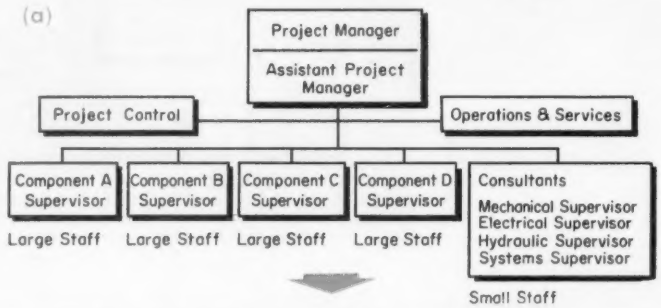
Project awarded to company.

Project manager named. Personnel, both specialists and generals, selected to start project and fill key positions.

Initial concept of hardware established. Project divided into hardware components.

Project-type organization established for concept stages.

(a)

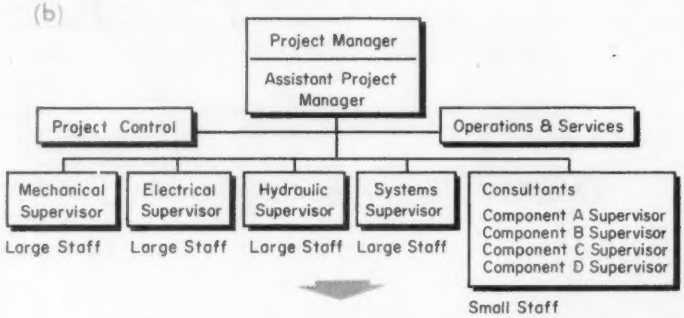


Concept finalized. Design specifications established.

Design and Manufacturing Stages

Functional-type organization established.

(b)

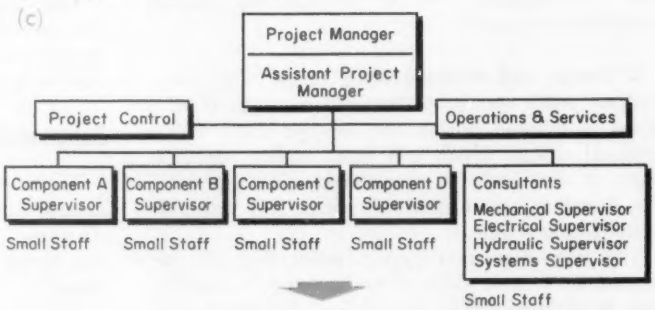


Hardware designed, drawings prepared, parts manufactured and assembled.

Testing and Completion Stages

Project-type organization established.

(c)



Project brought to completion while staff is progressively reduced.

Fig. 3—Convertible organization.

rated. Personnel are assigned from a completed project to a new project without falling back to any permanent organizational framework.

Advantages of this organization are clear-cut delegation of responsibilities by one leader, and greatly reduced problems of co-ordination.

Disadvantages include potential inconsistencies in technical work due to the absence of specialized knowledge, and lack of accumulation of technical know-how.

Take an example, Fig. 1. Hardware to be developed is divided into major components along logical lines of separation, but certain specialties such as electrical and servo work for the entire project are assigned to separate groups. There are several operational difficulties:

Loose managerial control results from the large span of activities. Groups may go off on their own without regard to the efforts of other groups.

Mixed functional and project organization creates serious problems. Duplication of effort is apparent while other jobs remain undone. Jurisdictional disagreements are commonplace and must often be resolved arbitrarily because the manager does not have time to get to the bottom of the problem.

Lack of uniformity of design results when separate groups handle similar problems differently. This and other cases of discrepancies become more and more embarrassing as the customer starts to notice them.

Functional Organization: A characteristic of functional organization is the existence of pools of specialists to provide specialized knowledge. Each pool is headed by a supervisor who is a specialist himself. He assigns men to various projects, but he himself is not available for assignment. Consider, for example, the engineering group from Fig. 1 recast in a purely functional organization, Fig. 2.

Functional organizations have certain advantages: Specialized talent is available when needed, and the company enlarges its storehouse of knowledge with each new project. The technical quality of hardware is enhanced by specialized attention. There is a uniform approach to similar problems, and results are consistent. The managerial span of control is continually at a workable level.

A disadvantage is that pool personnel appear to have two bosses—their permanent supervisor and the project manager on each job. Furthermore, projects require very effective co-ordination since specialists usually concentrate on narrow fields. Interface problems between adjoining components are the rule rather than the exception, and their resolution burdens the project manager.

Because functional philosophy may prevail both inside and outside the sections, each section has its own co-ordinator. These co-ordinators are to their sections what the project manager is to the whole project. They may be given group supervisory status and charged with the technical responsibility for the job to the section managers.

This intrasectional organization causes trouble. Engineers are saddled with two bosses—a violation of a basic principle of organization—and the co-ordinator is successful only when he commands respect.

The project manager fares no better. Having technical responsibility in a decentralized form, he has communication difficulties and lacks the first-hand knowledge needed to make decisions.

Convertible Organization

Comparison of organizational requirements in the various development stages with the different types of organizational frameworks shows a substantial similarity. The problem is to match requirements and structures. Adaptability to make this match is a feature of the convertible organization, Fig. 3.

Convertible Functions: Work proceeds toward completion of the concept stage under the direct lead of the various component supervisors. Consultants are called upon to insure technical consistency at an early phase. What they learn about component development enables them to perform their future duties better. They also have supervisory status and take part in frequent progress reviews with the component supervisors.

For the design and manufacturing stages, the organization of Fig. 3*a* is converted to that of Fig. 3*b*. Here the specialists take over to insure a high-quality product under the watchful eyes of component supervisors who resolve interface problems between their respective components. Direct line responsibility, however, belongs to the specialist supervisors for the duration of this stage.

In the testing and completion stage, the organization reverts to that in Fig. 3c. By this time, the specialist consultant's job slowly becomes a part-time one and they probably can phase out of the project by the time tests are completed.

Convertible Features: This elastic organization allows a close tie between the project and the organization. Despite its shifting nature, this setup retains the advantages of a more stable structure and combines them with features allowed by its flexibility.

A permanent core of key men is assured by making them part of the team at the beginning of the project and assuring them a place during all phases of development. An atmosphere conducive to teamwork is created by giving them status whether or not they have line responsibilities at the time.

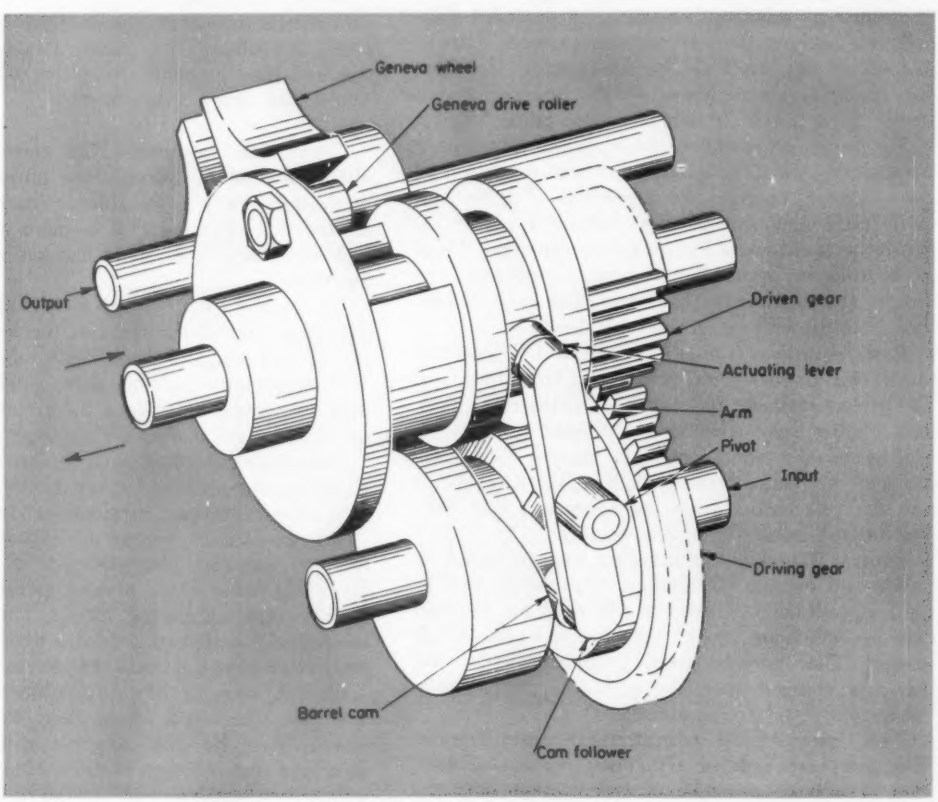
Around this permanent core, freedom is allowed in assigning personnel to jobs. Continuity is assured even when manpower requirements drop.

The inevitable changes in organizational structure are planned and publicized in advance. People know what their present status is and what can be expected in the future. They are at least assured of having one boss at a time, and not more than two during the life of the project.

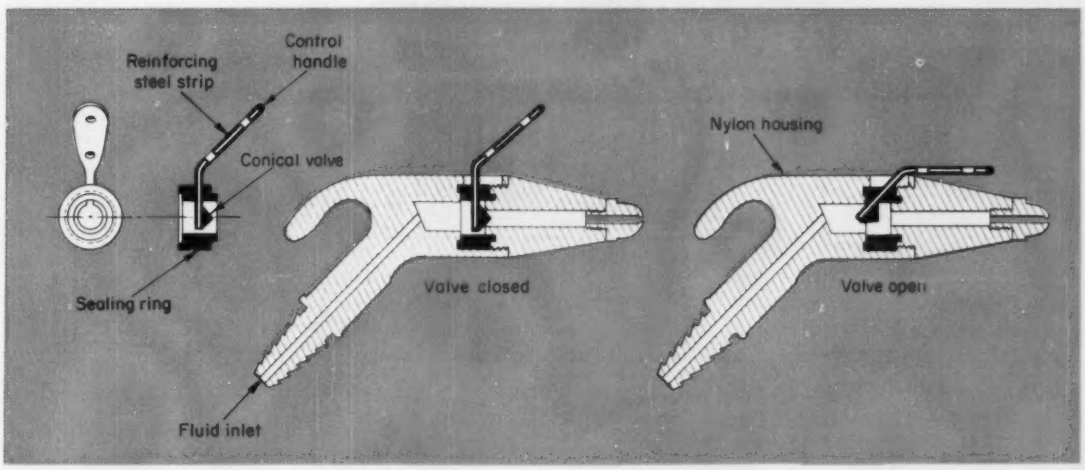
Finally, men of proper qualifications are made available when and where they are needed most. Results must be more effective utilization of their time, and improvement of the quality of the product.

scanning the field for *ideas*

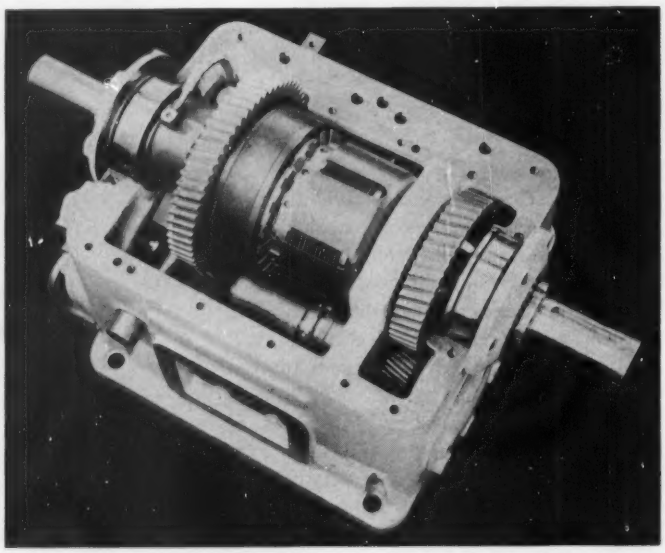
Interrupted indexing with constant speed input is accomplished by a Geneva drive with a built-in barrel-cam arrangement. A drive gear attached to a barrel cam drives the double-width gear on the center shaft which also holds the Geneva drive roller. The Geneva drive roller is revolved and engages the Geneva wheel. Also, the roller engaging the barrel cam pivots the lever, moving the center-shaft assembly to engage or disengage the Geneva driver. For the assembly shown, a 2:1 gear ratio coupled with the cam causes the Geneva drive roller to engage the four-station Geneva wheel on every other rotation of the input shaft. Any number of combinations can be obtained by changing the various elements. Drive designed by E. D. Hanson, Baltimore, Md.

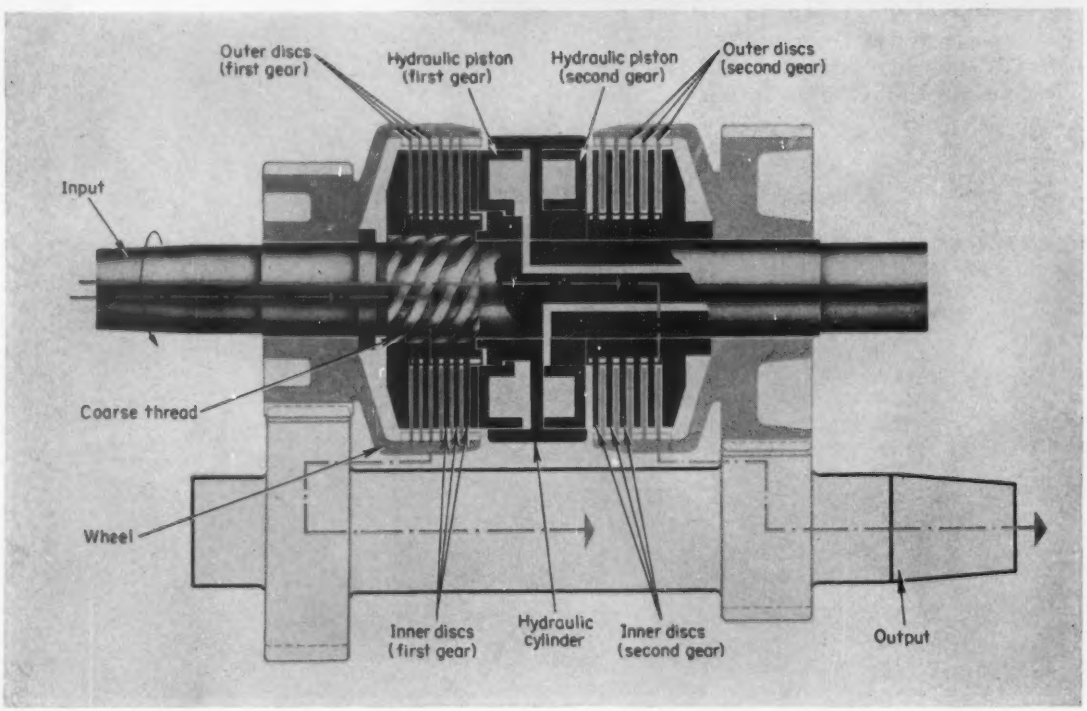


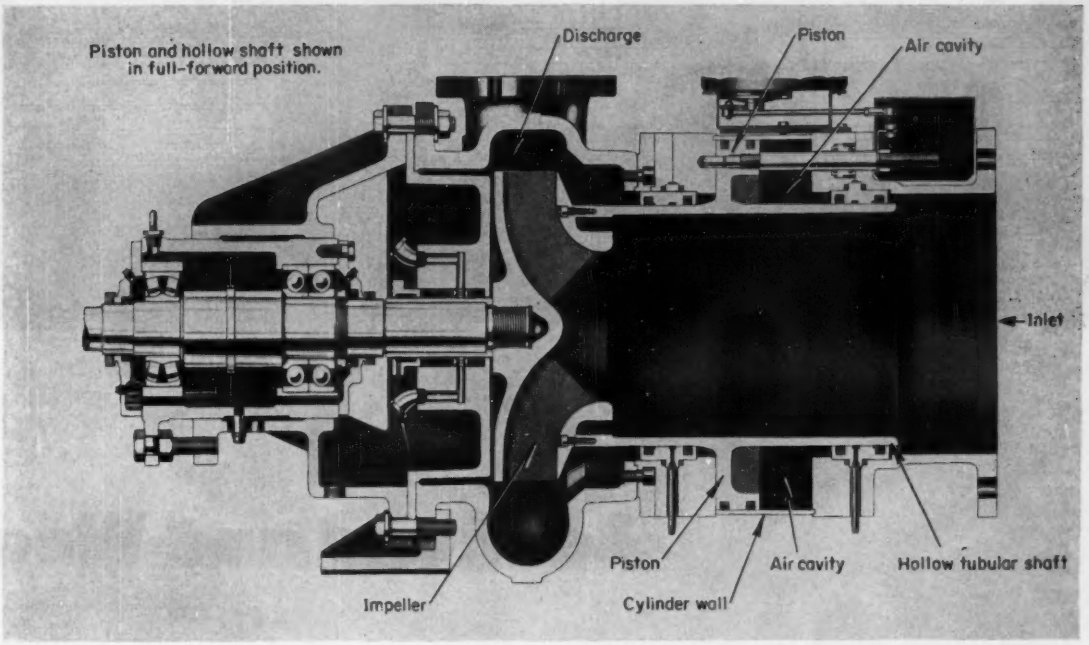
One-piece rubber valve, reinforced by single steel strip, controls fluid flow. A bonded nozzle assembly consists of an annular sealing ring, which contains the conical valve, and a protruding control handle. The handle extends through the sealing ring and carries the conical valve at its end. Control handle and valve flap are reinforced by a single steel strip. Once the rubber member is inserted, the sealing ring serves as fulcrum for control handle and valve flap. As the control handle is depressed, the valve opens against fluid pressure. If the handle is released, the valve is closed by the resilience of the sealing ring and the fluid pressure. Rubber valve principle employed in spray gun designed by AB Produktionsmateriel, Stockholm, Sweden.



Coarse-thread power screw on transmission input shaft shifts torque-transmitting discs to change speeds at full load without power drop at output. Before starting, the hydraulic piston of first gear is actuated by fluid pressure. Once the input shaft starts rotating in the direction of the arrow, the thread displaces the inner discs of the first gear to the right to engage the outer discs of first gear. The output shaft is then driven through the first-gear discs and wheel. The outer discs and wheels of both the first and second gear rotate freely about the input shaft. When the transmission is shifted to second, the hydraulic piston of the second gear is actuated by fluid pressure. The output shaft is then driven through the second-gear discs and wheel. Since the load on the unit determines the speed of the shafts, either the speed of output shaft increases or the speed of the input shaft decreases to maintain constant-power output. Hence, the inner discs of first gear rotate at a higher speed than input shaft, and the screw displaces the inner discs to the left, disengaging them from outer discs of first gear. The hydraulic piston of first gear remains actuated during operation. Thread shifting principle employed in multiple-disc transmission designed by Carl Hurth, Munich, Germany.

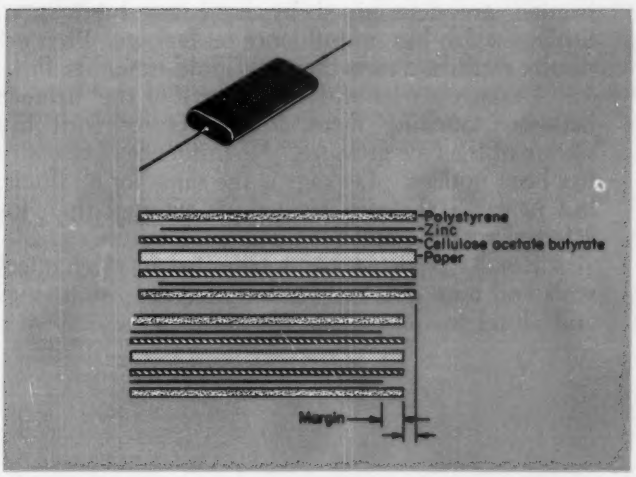




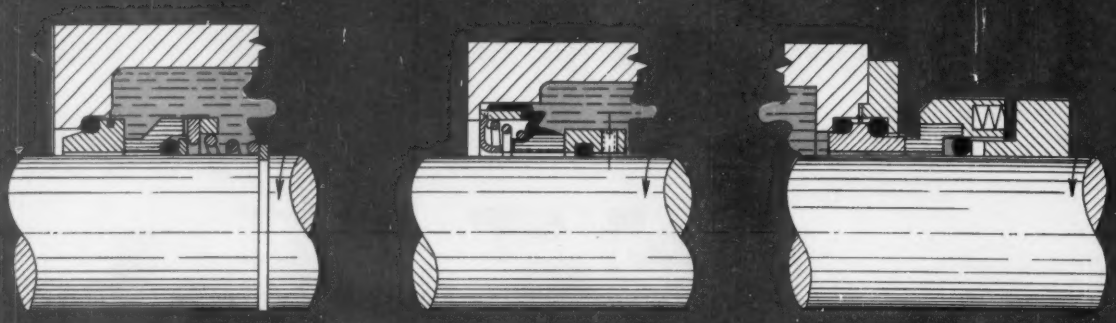


Movable air inlet controls flow and recirculation of fluid at pump discharge. An oversized tubular shaft of an air cylinder forms a movable hollow sleeve through which the flow passes when entering the intake. A specially shaped guide on the impeller end of the shaft forms the front face of the impeller. As air is fed to one side or the other of a piston on the exterior of the hollow shaft, the shaft is moved in the cylinder, regulating the flow through the impeller. Control principle employed in the ACAP pump developed by Allis-Chalmers Mfg. Co., Milwaukee. Wis.

Rolled capacitor design permits miniaturization of electrical circuits without loss of performance



efficiency. The miniature capacitors are formed by winding two lengths of layered material together. Each length of material has a paper core upon which successive layers of lacquer, zinc, and polystyrene are applied to either side. Each length has an unmetallized margin. The two lengths are put together so that, as they are wound, the margins are at opposing edges. This prevents molten metal solder, which is sprayed on to make terminals, from electrically shorting the two lacquered strips. Tinned copper leads are attached to the final unit for connections. Forming principle employed in a miniature capacitor developed by Bell Telephone Laboratories Inc., New York, N. Y.



(a) Internal Rotating Seal (b) Internal Stationary Seal (c) External Rotating Seal

Leakage and Wear

What are the major factors causing leakage and wear in mechanical seals?

Can leakage be calculated accurately?

What can be done to reduce leakage and wear?

Tests on unbalanced seals for 20,000 hours, with five face material combinations, and three different fluids, have given some answers:

No fluid pressure exists between seal faces, in contrast to previous theories. Leakage, wear, and friction are determined by boundary lubrication. Surface width has no influence on leakage. Physical results confirm a new theory of fluid-exchange flow.

Leakage varies with the square of the distance between touching faces, and inversely with the square of the face pressure. No influence of viscosity has been noticed. Leakage is the same for all fluids, but nearly 100 times greater for external than for internal rotating seals.

Results reported are not limited to mechanical seals and may also be used for oil seals, piston rings and clutches.

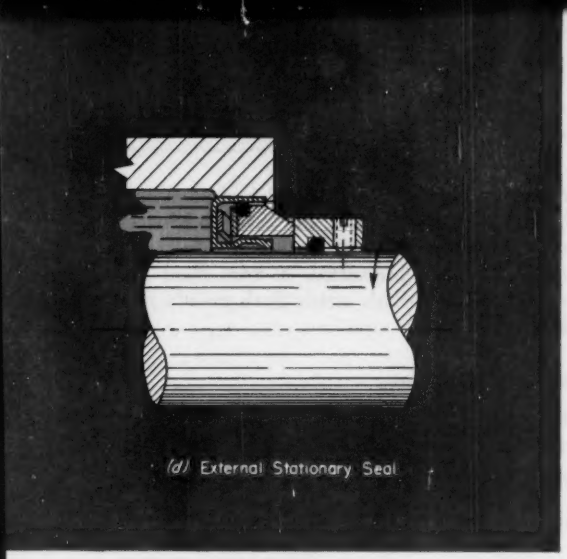


Fig. 1 — Installations of mechanical seals.

in Mechanical Seals

EHRHARD MAYER, Garlock Packing Co., Palmyra, N. Y.

BY CONVENTION, *mechanical seal* designates an assembly that forms a running seal between flat, precision-finished surfaces. Except in a few special designs, sealing surfaces are at right angles to the axis of shaft rotation. Forces which hold the sealing faces in contact are parallel to the shaft. In addition to sealing, a mechanical seal functions as a bearing and a heat exchanger.

Installations and Types

Four different installations of mechanical seals are recognized: Internal rotating, internal stationary, external rotating, and external stationary, Fig. 1. The most popular, with the best heat convection, is the internal rotating seal. If centrifugal forces are high, or if a press-fitted type is preferred, a stationary seal is used. Sometimes it is practical to use a rotating external seal, which is easy to install and observe, although heat conductivity is poor without a special cooling chamber, and flow of leakage is in the direction of centrifugal forces. The equation of the forces working in an axial direction for seals as in Fig. 1*a*, *c*, and *d* is

$$P_D = P_F + P_H - P_{Sp} \pm P_R \qquad (1a)$$

and for Fig. 1*b*,

$$P_D = P_F - P_H - P_{Sp} \pm P_R \qquad (1b)$$

Spring force P_F is always positive, and usually the hydraulic force P_H is also positive. Friction force P_R may be positive or negative depending on conditions. The force of the fluid gradient between the faces P_{Sp} tends to force the faces apart.

Neglecting P_R and P_{Sp}, unit face pressure in Fig. 1*a*, *c*, and *d* is

$$p_g = \frac{P_F + P_H}{F} \qquad (2a)$$

and in Fig. 1*b*,

$$p_g = \frac{P_F - P_H}{F} \qquad (2b)$$

If $p_g/p_1 < 1$, a seal is *balanced*, Fig. 2*a*. If $p_g/p_1 > 1$, a seal is *unbalanced*, Fig. 2*b*. Seals are also

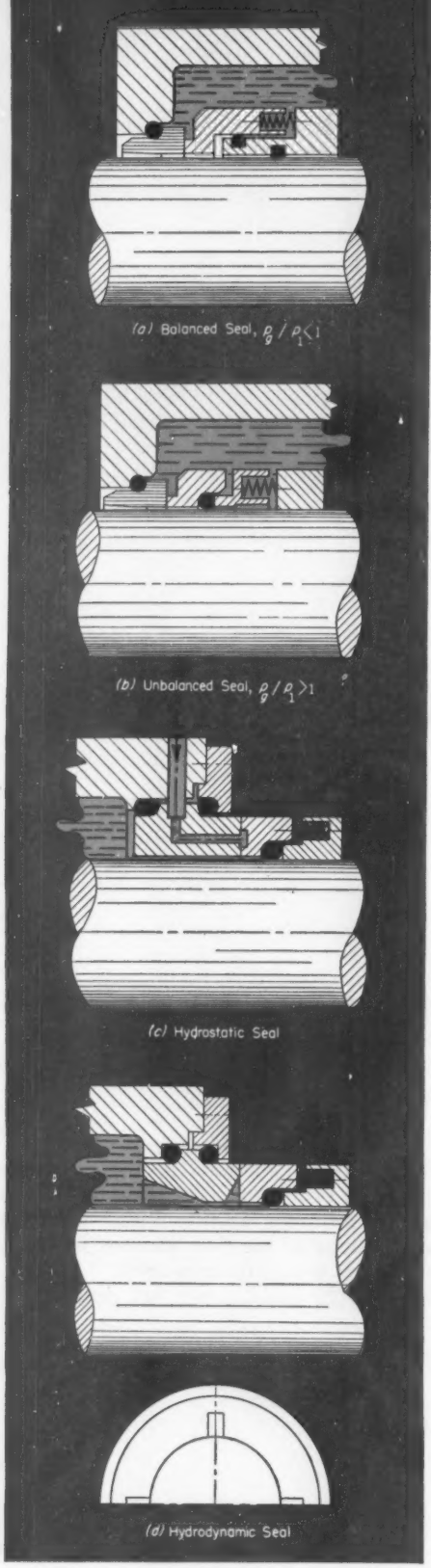


Fig. 2—Types of mechanical seals.

classified as hydrostatic, Fig. 2*c*, and hydrodynamic, Fig. 2*d*. In the hydrostatic seal, the pressure between the sliding faces is generated by a separate pump. A hydrodynamic seal pressurizes its own fluid film between sealing faces. This article deals mainly with unbalanced seals.

Performance Questions

Recent investigations of unbalanced seals sought answers to these questions:

1. Is it possible to calculate leakage of unbalanced

Nomenclature

A = Wear of face material, microinches per hr
$b = (D - d)/2$ = Surface width of contact area, in.
$D = 2R$ = OD of seal ring at contact area, in.
$d = 2r$ = ID of seal ring at contact area, in.
d_E = Diameter of fluid entrance, in.
$d_m = (D + d)/2$ = Mean diameter of contact area, in.
F = Area of seal ring, sq in.
f = Coefficient of friction
h = Vertical gap between touching seal faces, in. and microinches
h_o = Height of fluid film between seal faces, in. and microinches
M_R = Torque of seal, lb-ft
n = Speed of rotation, rpm
P_D = Thrust force on seal faces, lb
P_F = Spring force, lb
P_H = Hydraulic force, lb
P_R = Friction force of O-ring or U-cup, lb
P_{Sp} = Force of fluid pressure between faces, lb
p_1 = Internal fluid pressure, psi
p_2 = External pressure, psi
p_g = Face pressure, psi
p_s = Centrifugal pressure between faces, psi
Q = Leakage, cu cm per min or cu in. per sec
$r_g = \frac{2}{3}\left(\frac{R^3 - r^3}{R^2 - r^2}\right) \approx \frac{d_m}{2}$ = Sliding radius, in.
S = Gap factor, psi per sec
T = Seal-ring temperature, deg F
t = Fluid temperature, deg F
v_g = Average surface speed, fpm
α = Linear coefficient of thermal expansion, in. per in. per deg F
η = Dynamic viscosity, kg-sec per sq meter
λ = Thermal conductivity, Btu per ft per deg F per hr
γ = Specific density, grams per cu cm

Material Codes:

PC = Phenolic-impregnated hard carbon
PR = Filled phenolic resin
St = Stellite
CI = Cast iron
Br = Bronze

seals with the equation of laminar fluid flow?

$$Q = \frac{\pi d_m h_o^3 (p_1 - p_2)}{12 \eta b} \qquad (3)$$

What is the influence of surface finish and face pressure on leakage? What is the pressure distribution on seal faces?

2. How strongly do different face pressures, fluids, and thermal properties influence wear of face materials?

3. What condition of lubrication is present in unbalanced seals? What about coefficient of friction and power absorption? Is there a value of a *pv* factor, which would apply to other seals and materials?

Two types of rotating seals were tested: An external seal on a 2 13/32-in. diameter shaft, and an internal seal on a 1-in. diameter shaft. Face materials were selected for their different thermal conductivities λ, Table 1. Combinations tested were (see Nomenclature): PR/St, PR/CI, PR/Br, PC/St, and PC/Br. Properties of three selected fluids are listed in Table 2. Test conditions were:

Fluid temperature, t = 70 to 200 F
Fluid pressure, p_1 = 72 psi
Average surface velocity, v_g = 1000 fpm
Face pressure, $p_g > p_1$; p_g/p_1 = 1.3 to 4.0
Duration of each test, 100 and 300 hr
Wear measured after 100 and 300 hr

Results and Recommended Practices

Leakage of Seals: Matters pertinent to the leakage of seals include: Pressure distribution on seal faces, fluid exchange flow, measured leakage, and a gap factor equation.

Pressure Distribution on Seal Faces: Shifting pressure distribution in a balanced seal having rough seal surfaces is shown in Fig. 3. There, $p_g/p_1 = 0.9$, and gap h = 120 microinches. With passage of time, fluid pressure on sealing faces did not drop, but increased. The same results were obtained by other investigators. The pressure increase seems to be caused by hydrodynamic effects of the pressure-sensing holes in the face.

Other tests with smoother surface finishes on the faces and changed ratio p_g/p_1 showed no pressure between the faces although there was leakage all the time and tests ran 100 hr. The curve in Fig. 4 shows the region where fluid film has no pressure. If lapping powder is added to a closed circulating fluid system with a balanced seal, $p_g/p_1 = 0.7$, after some minutes leakage will increase rapidly and suddenly the faces will open. Therefore, if surface finish becomes too rough, internal fluid pressure will advance all across the surface width and will open a balanced seal. An unbalanced seal would never fail by opening seal faces.

Table 1—Thermal Properties of Sealing Face Materials

Material	High Temperature Limit T (F)	Coefficient of Linear Thermal Expansion Range: 68 F to 572 F α(in./in./deg F)	Thermal Conductivity λ(Btu/ft/deg F/hr)
Filled phenolic resin (PR)	250	10 to 17 × 10^{-6}	0.45
Phenolic-impregnated hard carbon (PC)	350	2.7 × 10^{-6}	2.7
Stellite (St)	>1500	6.7 × 10^{-6}	6.7
Cast iron (CI)	>1000	5.6 × 10^{-6}	30.0
Bronze (Br)	1000	9.6 × 10^{-6}	34.0

Table 2—Properties of Fluids at High Temperatures

Fluid Temperatures	Water η*	Water γ†	Diesel Fuel η	Diesel Fuel γ	Mobil Oil Arctic η	Mobil Oil Arctic γ
68 F	10.2 × 10^{-5}	0.998	2.72 × 10^{-4}	0.825	15.6 × 10^{-3}	0.88
122 F	5.5 × 10^{-5}	0.988	1.48 × 10^{-4}	0.804	3.25 × 10^{-3}	0.86
212 F	2.88 × 10^{-5}	0.958	0.6 × 10^{-4}	0.769	0.70 × 10^{-3}	0.825
302 F	.....	0.917	0.3 × 10^{-4}	0.734	0.28 × 10^{-3}	0.79

*Dynamic Viscosity (kg-sec per sq meter)
†Specific Density (grams per cu cm)

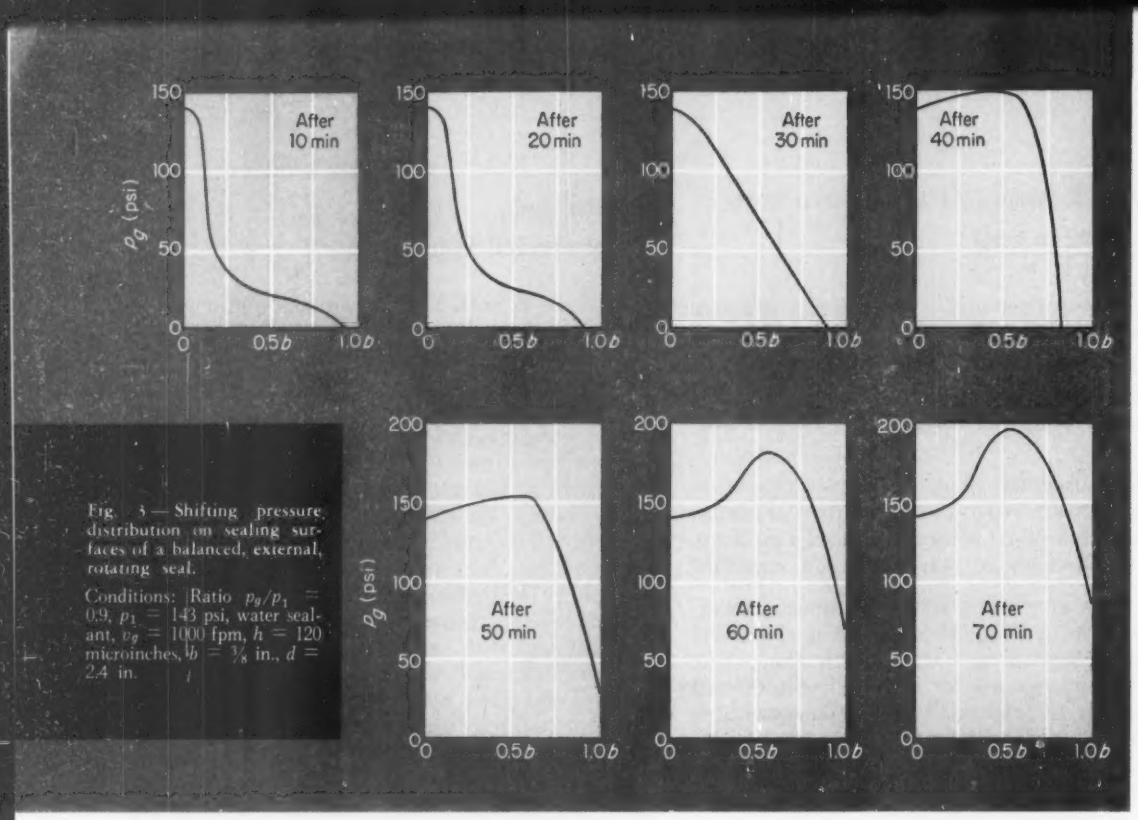


Fig. 3 — Shifting pressure distribution on sealing surfaces of a balanced, external, rotating seal.

Conditions: Ratio p_g/p_1 = 0.9, p_1 = 143 psi, water sealant, v_g = 1000 fpm, h = 120 microinches, b = 3/8 in., d = 2.4 in.

MECHANICAL SEALS

FLUID EXCHANGE FLOW: If there is no fluid pressure between sealing faces, and the seal leaks, fluid flow must occur some way other than hydrodynamically. The following explanation may account for this phenomenon.

By the strong throttle effect of the small gap between the faces, internal pressure p_1 drops to zero at the diameter of entrance d_E. The fluid advances through small scores and microcanals. These hollow spaces and excavations are not always connected. Therefore, when the seal is rotating, there is an exchange of fluid from one face pit to another, and centrifugal pressure forces the fluid to leave the gap.

As long as fluid flow and exchange are in balance, there is no pressure between the faces. If the surface roughness is equal across face width b, leakage is not influenced by the surface width, but strongly influenced by surface finish, face pressure, and the amount and direction of centrifugal forces. These tests confirm this suggestion of a fluid exchange flow. It is further supported by the fact that mechanical seals may be absolutely fluid-tight if there is no rotation, but show a growing leakage with increasing velocity.

MEASURED LEAKAGE: From a comparison of actual measured leakage with the calculated rate of leakage by Equation 3, there was no correlation evident. In changing surface width b, no change of leakage was noticed and no influence on dynamic viscosity was found. But, by increasing face pressure p_g, leakage decreased very noticeably.

GAP FACTOR: A specially developed expression, Equation 4*a* or 4*b*, for the vertical gap h between touching faces takes into consideration maximum and average peak-to-valley height of both faces. Leakage is seen to vary with the square of surface finish. Good results were obtained for leakage of unbalanced seals ($p_g > p_1$; $h < 2000$ microinch). The equation is

$$Q = \frac{\pi d_E (p_1 - p_2 \pm p_z) S h^2}{p_g^2} \text{ (cu in. per sec)} \qquad (4a)$$

or, in metric units,

$$Q = \frac{984 \pi d_E (p_1 - p_2 \pm p_z) S h^2}{p_g^2} \text{ (cu cm per min)} \qquad (4b)$$

In both versions, flow from d to D is positive, and flow from D to d is negative.

Gap factor S does not vary with changing viscosity η. This confirms the supposition that fluid flow does not obey known hydrodynamic laws. Tests showed for the external seal a factor $S = 47.2 \times 10^5$ psi per sec and for the internal seal $S = 38.6 \times 10^3$ psi per sec. All tests showed a leakage for an external rotating seal 100 times that of an internal rotating seal. Fluid exchange flow under influence of centrifugal force may account for the difference.

For unbalanced seals, b and η have no influence.

Table 3—Wear and Computed Gap for Fluids and Materials

Test conditions: v_g = 1000 fpm; p_1 = 72 psi

Sealed Fluids At Face Pressures	Combinations of Sealing Face Materials									
	PC-St		PC-Br		PR-St		PR-CI		PR-Br	
	A*	h†	A	h	A	h	A	h	A	h
Water:										
p_g = 95 psi	120	144	4	200	20	208	2	96	16	84
145	260	244	6	208	128	300	6	52	32	212
215	600	412	8	248	284	480	5	30	160	640
Diesel Fuel:										
p_g = 95 psi	3	80	24	140	2	72	6	64	48	548
145	3	88	4	120	24	252	2	42	168	840
215	6	104	16	288	44	120	11	40	324	1200
290	10	244	28	500	108	112	36	100	—	—
Mobil Oil Arctic:										
p_g = 95 psi	2	68	1	168	4	140	8	123	12	328
145	8	80	2	240	8	60	3	66	20	740
215	3	20	4	124	11	228	5	212	44	1000
290	10	22	5	36	—	—	—	—	—	—

* Wear of face material, microinches per hour.

† Gap between sealing faces, microinches.

Leakage varies with the square of surface finish and inversely with the square of face pressure. Hence, when smoothness of surface finish and face pressure are both doubled, leakage will drop to 1/16 of its former rate.

Wear: Factors pertinent to the wear of seals include mechanical load and thermal load.

MECHANICAL LOAD: No single factor alone causes wear. In these tests, seals were installed with vibration-damping rubber rings so that wear caused by vibration can be neglected. Wear rate in the first 10 hr is high, then levels off. Usually with increasing face pressure, mechanical wear goes up, Table 3, but only tests may give the exact answer.

THERMAL LOAD: When fluid temperature is high, special consideration should be given to prevent the lubricating fluid film between the faces from vaporizing. If both face materials, such as PR-St and PC-St, have poor thermal conductivity, wear is very high. These same materials have high coefficients of friction f. Conditions leading to thermal failure are: Poor thermal conductivity does not permit friction heat of the faces to be removed; the thin lubricating film vaporizes particularly if b is

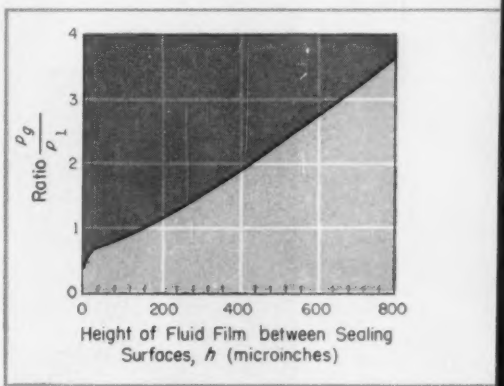


Fig. 4—There is no pressure in the fluid film between sealing surfaces in the shaded area above the curve, although leakage occurs.

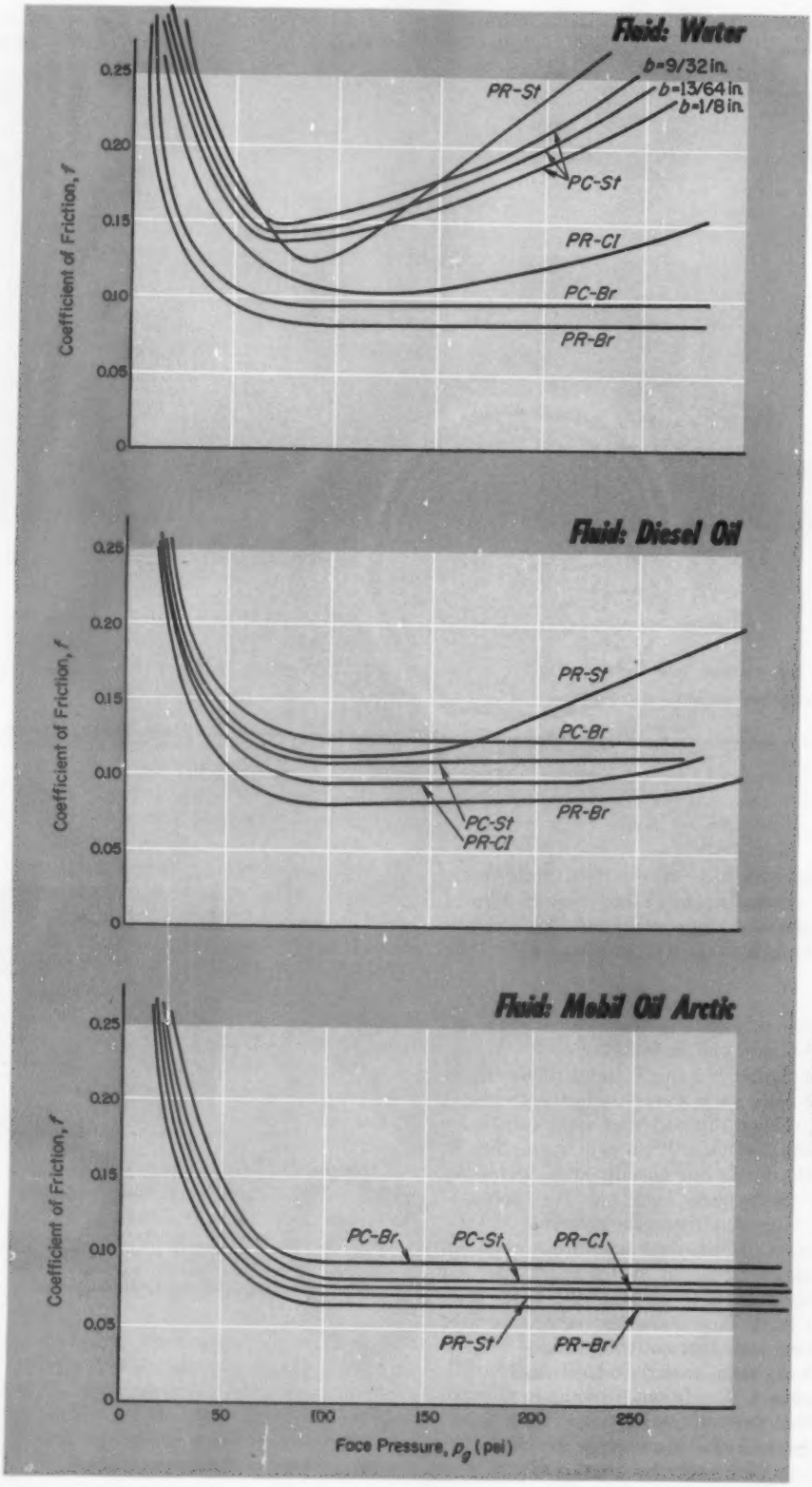


Fig. 5 — Variation of the coefficient of friction with no pressure between the sealing surfaces, for different fluids.

Table 4—Coefficients of Friction: Values and Conditions

Lubrication Condition	Coefficient of Friction	Wear	Type of Seal
Full film	0.001 to 0.05	None	Hydrodynamic, hydrostatic
Mixed film	0.005 to 0.1	Little	Balanced, (unbalanced)
Boundary film	0.05 to 0.15	Moderate	Unbalanced, balanced
Dry running	0.1 to 0.6	Heavy	(Unbalanced)

wide, Fig. 5; and the seal runs dry with a much higher coefficient of friction and wear rate.

In the design of seals, remember that water is an excellent fluid for a heat exchanger, and oil a very poor one. Consideration also should be given to the structure of housings and seal rings to prevent pressure and thermal distortions which may destroy the flatness and squareness of the seal faces.

Friction and Power Absorption: Mechanical seals may show different conditions of lubrication:

FULL-FILM LUBRICATION: Types are self-pressurized or hydrodynamic, and pump-pressurized or hydrostatic. Both obey Newton's formula for shearing stress. There is no wear.

$$\tau = \eta \frac{dv_g}{dh_o} \text{ (psi)} \qquad (5)$$

BOUNDARY LUBRICATION: A very thin boundary film produces no pressure between the faces. There is no influence of dynamic viscosity; the coefficient of friction is constant if $p_g > 93$ psi; and f does not vary with velocity. Wear is moderate.

TECHNICAL DRY RUNNING: There is no fluid between the faces which are in firm contact. Usually friction can be calculated with formula of Coulomb, but not for all materials, and particularly not for phenolic resins and carbons. Wear is heavy.

MIXED-FILM LUBRICATION: Mixture of full-film and boundary lubrication. There is little wear. The torque of a mechanical seal is

$$M_R = F p_g r_g f \text{ (lb-in.)} \qquad (6a)$$

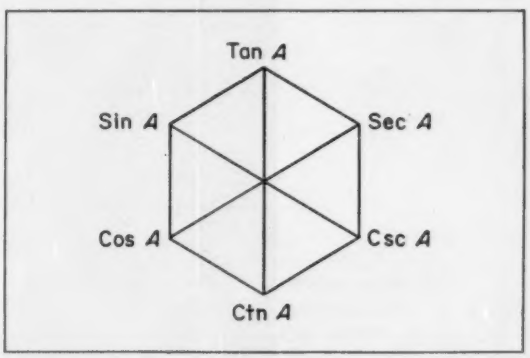
$$M_R = \frac{\pi d_m^2 b p_g f}{24} \text{ (lb-ft)} \qquad (6b)$$

Representative, calculated coefficients of friction of the tests are shown in Fig. 5. If the lubricant between the faces does not vaporize, these curves are typical for boundary lubrication. The coefficient of friction f is very high at low face pressure p_g until it levels off, at $p_g = 93$ psi and remains at this level regardless of changing velocities. Rule-of-thumb values appear in Table 4.

Seal manufacturers try to give a pressure-velocity limitation for mechanical seals—the so-called pv factor. The figures are determined by wear, friction heat, and face conditions. If exact values of this factor are needed, it should be expressed as a $p_g v_g f$ factor (lb-ft per sq in. per min). This form gives the generated friction heat per face area unit of the seal ring. If the coefficient of friction is constant, the value of a $p_g v_g f$ factor is very important, especially for boundary lubrication conditions.

Tips and Techniques

Trigonometric Functions



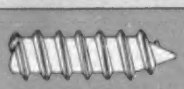
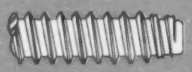
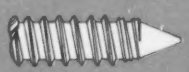
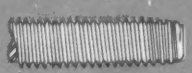
This easy-to-remember hexagon diagram relates several trig functions and identities:

1. Any function equals the product of the two functions on either side. EXAMPLE: tan A = sin A sec A.
2. The product of the functions at any three alternate vertices equals 1. EXAMPLE: tan A csc A cos A = 1.
3. Any function may be expressed as a fraction whose numerator is either of the two adjacent functions, and whose denominator is the function next beyond the numerator. EXAMPLE: tan A = sec A/csc A.
4. The product of the two functions at the ends of any diagonal equals 1. EXAMPLE: sin A csc A = 1.
5. The functions at the ends of any diagonal are reciprocals of each other. EXAMPLE: tan A = 1/ctn A.

—F. MURRAY, *Chicago, Ill.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, *Penton Bldg., Cleveland 13, O.*

Table 1—Standard Tapping Screws

ASA Type	Form
Thread Forming	
A	
B	
BP	
C	
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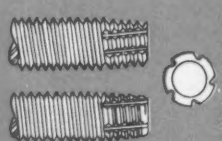
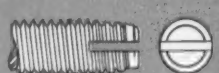
F	
G	
T	
BF	
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Selecting and applying

Tapping Screws

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General American Transportation Corp., Clifton, N. J.

THE first "sheet-metal" screw was based on a simple idea: A hardened screw will tap its own mating thread in metal parts. Today's tapping screws are a direct outgrowth of this concept. Available in a number of standardized types and styles, these screws form a family of effective fastening devices developed to meet a broad range of application and material requirements.

General specifications and dimensional data for standard tapping screws are covered in *American Standard Slotted and Recessed Tapping Screws and Metallic Drive Screws*—ASA B18.6.4-1958. Practical factors influencing selection and application of the different screw types to meet specific design requirements are presented here.

Tapping screws fall into two general classifications: 1. Thread forming. 2. Thread cutting. Based on ASA designations, screw types A, B, BP, C, and U are in the first group and types F, BF, G, BG, D, T, and BT are in the latter group. Physical forms of the different screw types are compared in Table 1. All are manufactured to close tolerances and are case hardened to produce a secure assembly.

The general method of fastening two or more sections together with tapping screws is to drill, clean punch, or extrude a clearance hole slightly larger than the screw diameter through all but the last thickness of material. This section must contain a pilot hole of specific diameter. These hole sizes have been established by screw manufacturers on the basis of actual laboratory tests. Just any pilot-hole diameter somewhere between the minor and major diameter of the screw is not sufficient. Sometimes, the actual engagement of the tapping screw in the hole may not exceed 0.010 in. and yet a surprisingly strong joint is obtained. Density, hardness, and ductility, as well as other physical characteristics of the engaged material may have a significant effect on pilot-hole size. This point is discussed more fully later.

Thread-Forming Screws

Tapping screws in the thread-forming classification produce a secure joint by displacing or forming

*Chairman of the subgroup on tapping-screw threads for slotted and recessed head screws within ASA Sectional Committee B-18.

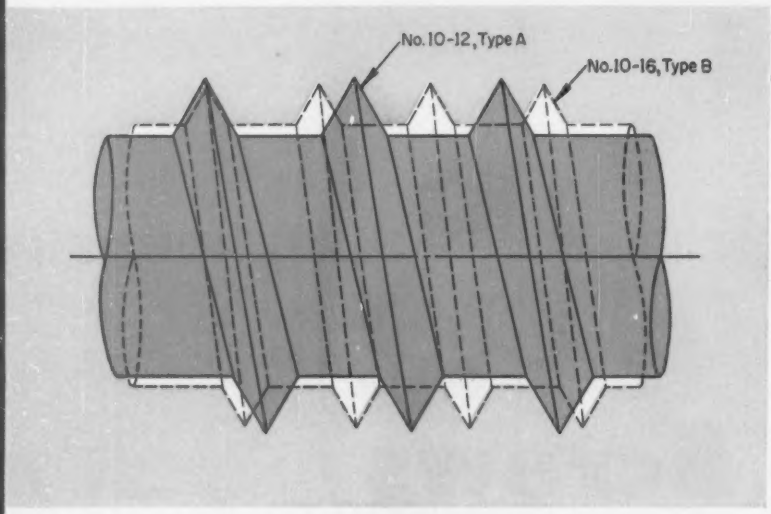


Fig. 1—Comparison of thread forms on Type A and B tapping screws No. 10 size.

the material adjacent to the pilot hole so that it wraps around the screw threads. There is actually no material removed from the engaged section. In this way, the mating parts form a perfect fit with a zero clearance. Since screw fasteners depend upon friction for a secure joint, the thread-forming screw most nearly attains this ideal with a minimum of tightening torque and without the addition of lock washers or other locking devices in most cases.

Although similar in thread action, the various types of thread-forming screws have certain basic differences.

Type A is a spaced-thread screw with a gimlet point. It is recommended for use in light sheet-metal parts where the thickness does not exceed 0.048 in. (18 gage).

Type B is a spaced-thread screw of finer pitch than Type A and has a blunt point with incomplete and tapered starting threads. It can be used in both light and heavy-gage sheet-metal parts, provided the mounting holes are in alignment.

Type BP is essentially the same as Type B except that it has a cone point to facilitate assembly in misaligned holes.

Type C is a blunt-point screw with threads of the same pitch as a standard machine screw. It is recommended for use in the lighter metal gages where the finer-pitch machine-screw thread is desirable and chips from a thread-cutting screw are objectionable.

Type U is a multiple-thread drive screw with a blunt point. Threads have a large helix angle. This screw is designed to provide a permanent fastening and is not recommended where removal is anticipated.

Recommended practices for the different thread-forming screws are influenced by several factors. Consider first the Type A and B screws, Table 1.

Why are both types needed? Also, why are Type A screws not recommended for sheet-metal thicknesses greater than 0.048 in.?

Actually, there is no hard and fast rule governing choice between the two types. However, laboratory tests have shown conclusively that the Type A screws produce a stronger joint in light-gage sheet metal. Fig. 1 shows the relative thread size of No. 10 Type A and B screws. In this nominal size, the Type A screw has the smaller root diameter and the larger outside diameter, giving a larger actual thread area. Naturally, the holding power of the screw is increased when the thread engages more deeply into the mating piece. This property becomes particularly important when the thickness of the mating material may be only 0.015 to 0.020 in. This fact alone is sufficient reason for the existence of the Type A tapping or, as it is often called, sheet-metal screw.

The reason for limiting general recommendations for Type A screws to sheet-metal thickness of 0.048 in. and less is also based on thread-size relationships. In many applications of this type, the gimlet point serves to align holes. Misalignment adds an additional driving-torque load to the screw because a partial thread is being formed in the attached thickness of material, at least until the holes are finally brought into alignment.

As shown in Fig. 1, the large thread area of the Type A screw is accompanied by an increased thread pitch. Thus, the screw travels farther for each complete revolution. But, the required driving torque is increased.

Thus, if the material in which the screw engages is near the maximum-thickness recommendation and the attached material equals or exceeds this thickness, a point is reached where the screw is no

longer useful. Because of these limitations, no general recommendations are made. Nevertheless, there are still many special situations where Type A screws can be successfully used.

The Type B tapping or sheet-metal screw was designed for use in heavier gage materials where the Type A is not recommended. It also may be used sometimes in place of the Type A where the protruding point is objectionable.

Since the Type B screw has a finer pitch, it requires less driving torque. Design of this screw also includes a starting pilot with predetermined taper. When the screw is started into a pilot hole of correct size, it is held upright by this taper, making it easier to drive. The starting threads on the taper aid the screw by forcing or extruding the metal more gradually. A Type B screw also can withstand greater loads in tension and torsion than a Type A screw of equivalent size because of the larger load-bearing cross section area.

Type A screws are not practical for use in metallic castings because of the very nature of their design. The Type B, however, has shown encouraging results in nonferrous castings. These metals are ductile enough to flow around the screw threads relieving the stresses developed by the screw as it forms a thread in the material. This condition is not true of ferrous castings which are too hard and brittle for any of the thread-forming screws. Here, one of the thread-cutting screw types, which are discussed later, must be used.

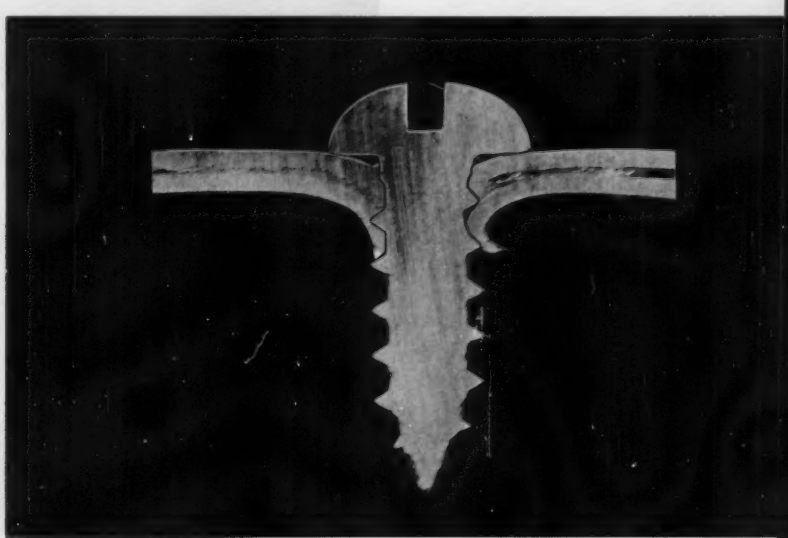
Castings usually consist of relatively heavy sections in which a blind hole is provided for assembly of the tapping screw. For this reason, recommendations of screw manufacturers include the pilot-hole diameter and the minimum screw penetration (with allowance for the tapered pilot), that are required for a secure fastening.

Recommendatons for use of tapping screws in plastics closely parallel those for metallic castings. That is, the cellulose acetates and nitrates, as well as the acrylic and styrene resins, have the characteristics of nonferrous castings. The phenolic group, which consists of very brittle materials, behaves in many ways like ferrous castings.

In plastic parts, the Type A screw, which is not able to stand vertically when started into the pilot hole, will usually develop sufficient stress to precipitate cracking around the boss, even when the edge of the hole is rounded.

The Type U drive screw which is designed to provide a simple, strong, and permanent fastening can be used to advantage in sheet metal, castings, or plastics if a few simple recommendations are followed. Here again, the pilot hole is of prime importance. But equally important is the thickness of the material in which the screw will engage. As a general rule, this thickness should not be less than the outside diameter of the screw. A clearance hole is not always necessary in the attached material, except to reduce the force required to drive the screw. However, with plastic parts, a clearance hole is advisable to reduce the possibility of breakage.

Standard drive screws do not have a head recess. They can, of course, be manufactured with a slotted



Round-head, Type A tapping screw (No. 8-15 × ½ in.) assembled in two 0.025 in. thick sheet - metal sections with extruded holes

head. However, because of the large helix angle such screws cannot be readily backed out or replaced with a screwdriver.

The Type C screw was designed primarily to fill a special need. It provides a tapping screw with a machine-screw thread that does not form chips on assembly. This feature offers advantages in certain applications such as electrical or electronic equipment, where chips or dust produced by a thread-cutting screw would be objectionable or hazardous. In hard materials, or where a long thread engagement is required, Type C screws may require a high driving torque for assembly. At the same time, these screws are well suited for sheet-metal joints and can be analyzed on the same basis that was used earlier for comparison of Types A and B.

Thread-Cutting Screws

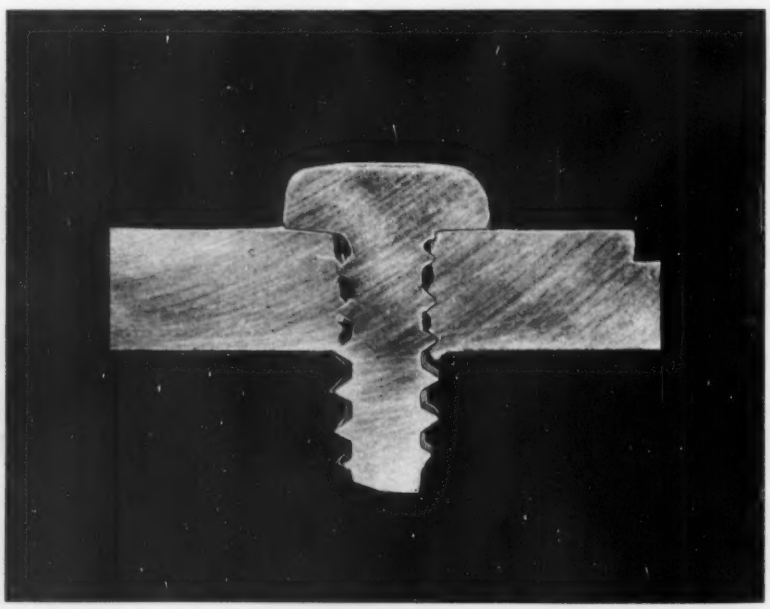
Tapping screws in the thread-cutting group have cutting edges and chip cavities to produce a mating thread by actual removal of material from the engaged section. The various types of these screws can be separated into two main categories, based on thread form.

Types F, G, D, and T are blunt-point screws with threads of the same pitch as standard machine screws. All have tapered entering threads with one or more cutting edges and chip cavities. In general, these screws are suitable for use in aluminum, zinc, and lead die castings; steel sheets and shapes; cast iron; plastics, etc.

Types BF, BG, and BT are spaced-thread screws with blunt points and one or more cutting edges and chip cavities. These screws can be used in plastics, die castings, plywoods, asbestos, and other compositions.

Recommended practices for thread-cutting screws vary with the screw type and the manufacturer. Design of chip cavities and cutting edges is different for each screw type, leading to variations in thread-cutting action and screw performance. For best results in specific applications, manufacturer's recommendations should be closely observed in specifications. In situations where screw choice is not clear-cut, comparative testing of different screw types may be helpful as a guide.

In general, thread-cutting screws in the first category (machine-screw thread pitch) were developed primarily for use in brittle or granular materials, or in materials which are easily pulverized. The Type F screw, for example, has a tap-spiral fluted, tapered pilot which functions like a tap to cut away the material as the screw is torqued into the pilot hole. It is ideally suited to the granular structure of cast-iron where a thread-forming screw would re-



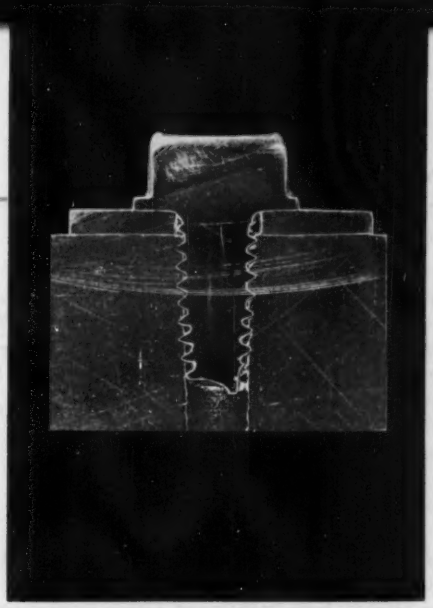
Pan-head, Type B tapping screw (No. 8-18 × 3/8 in.) driven into 1/8 in. thick cold-rolled steel section.

quire excessive driving torque. Contrary to what might be expected, the thread cut by a screw of this type is not quite the same as that produced by a standard tap. Thread pitch is the same but depth of cut is somewhat less. However, all of this thread, which has zero clearance, represents holding power. On the other hand, a standard Class 2A machine screw in a commercially tapped hole has a much lower percentage of actual thread engagement and, therefore, tends to be less resistant to vibration effects unless some form of locking device is used.

As compared to thread-forming types, these thread-cutting screws require a lower driving torque in assembly. Since the major diameter of these screws is held to the maximum dimension in manufacture, they can be replaced by standard machine screws for emergency repair or maintenance in service.

Although it doesn't happen often, operating requirements occasionally may call for the use of a nut with these screw types. Standard nuts, which are tapped to the minimum dimension, should be avoided. Instead, special nuts tapped to the maximum dimension should be specified to assure a proper fit.

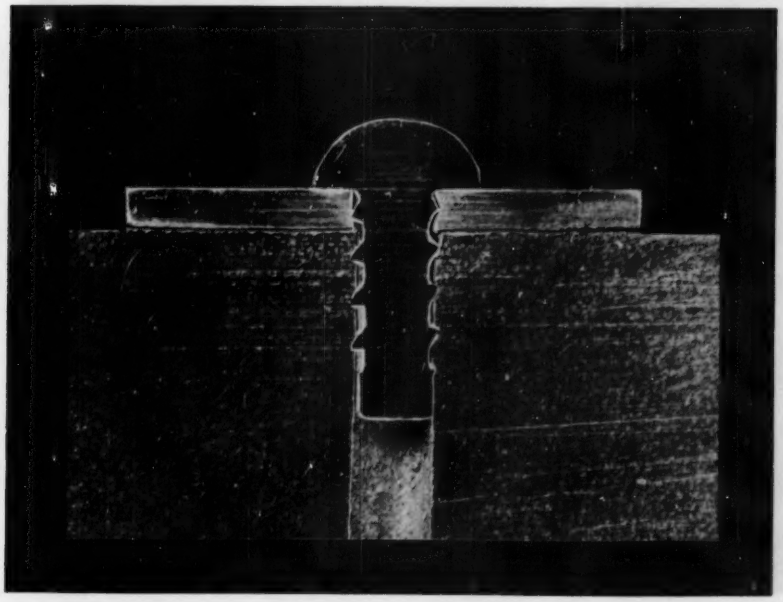
The second group of thread-cutting screws (Types BF, BG, and BT) were developed primarily for use in very friable plastics, such as the urea compositions. In these materials, a larger space between threads is required to produce a satisfactory joint.



Hex-head, Type F tapping screw (1/4-20) in cast iron.

Type BF screws, for example, represent a combination of the cutting flutes of Type F with the thread design of Type B.

These screws are usually assembled into holes molded in the plastic part with a slight taper to facilitate ejection of the part from the mold. Mean dimension of the hole should conform to the recommended size for a drilled hole, and the entering edge of the hole should be countersunk or rounded



Type U drive screw driven into cast iron.

to prevent spalling. Blind holes should provide at least 1/32-in. clearance for a chip cavity. When bosses are required in a plastic part, the general rule is that minimum wall thickness should be at least 1½ screw diameters. For island bosses, this minimum drops to one screw diameter.

Application Details

Efficiency and performance of tapping screws are influenced by a number of factors. Some of these have already been mentioned. Other important general rules and concepts of good design practice are summarized here.

1. Use tapping screws only in materials softer than the screw thread surface. Otherwise, stripping of the threads will result. Where screw and part are of same material, two alternatives are possible. If material can be hardened, specify screw for hardened condition and part for unhardened condition. If material is not hardenable, use screw of harder material to tap hole, then replace with screw of proper material.

2. Observe recommended hole sizes. Tapping screws should always be "driven" into place to develop proper thread action and holding power. Manufacturers recommendations are based on laboratory tests to provide the best relationship between driving, tightening, and stripping torques. Ideally, tightening torque should be about 2/3 to ¾ of stripping torque. This value leaves a safety margin for variation in torque output of driving tool. For driving torque, a value of about ½ the tightening torque is considered optimum.

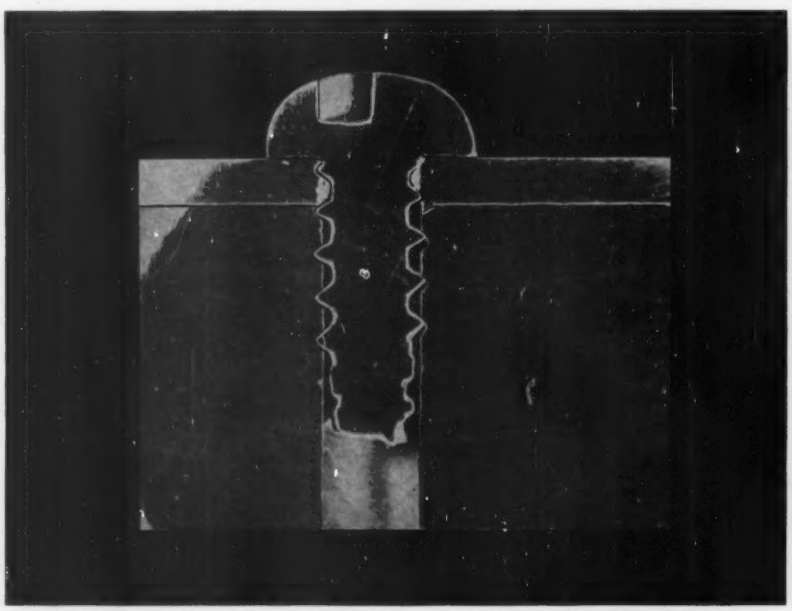
3. Specify extruded hole in light-gage sheet-metal parts to develop maximum clamping power. Extruded metal, which projects from part surface, acts to increase effective thickness of material for thread engagement. Pierced hole produces similar effect but to lesser degree. Clean punched holes or drilled holes give the least desirable results under such circumstances.

4. Provide countersink or radius on starting edges of holes in die castings and plastics. This practice is always desirable although it can be omitted on sheet-metal parts.

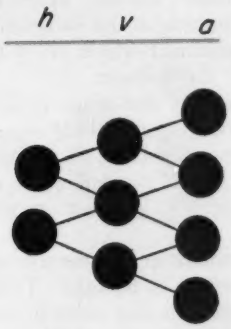
5. Allow clearance for pilot section on end of tapping screw. These screws should not be used where flush assembly is required.

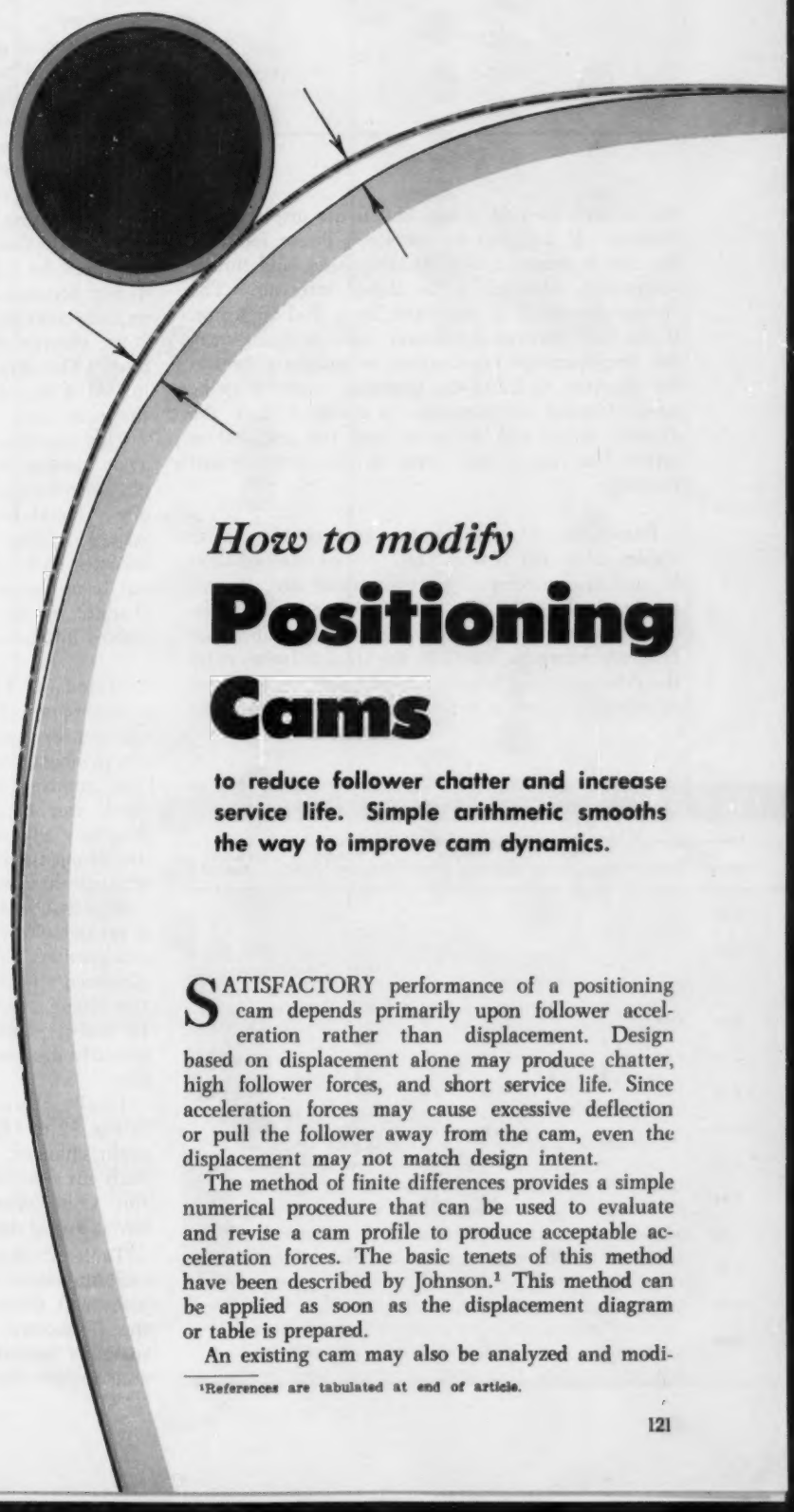
6. Use mean diameter in tapered holes as a basis for tapping screw selection.

7. Consider assembly requirements in specifying screws for light-gage sheet-metal parts. In parts of 24-gage metal or thinner, there is a tendency to overdrive and strip partial threads near screw head. For such applications, specify fully threaded screws with undercut at head to permit expansion of metal in last few threads. Also, keep in mind that a longer screw than necessary for engagement can sometimes simplify handling problems in the assembly operation, with a beneficial effect on overall costs.



Type BF tapping screw in Bakelite part.





How to modify

Positioning Cams

to reduce follower chatter and increase service life. Simple arithmetic smooths the way to improve cam dynamics.

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SATISFACTORY performance of a positioning cam depends primarily upon follower acceleration rather than displacement. Design based on displacement alone may produce chatter, high follower forces, and short service life. Since acceleration forces may cause excessive deflection or pull the follower away from the cam, even the displacement may not match design intent.

The method of finite differences provides a simple numerical procedure that can be used to evaluate and revise a cam profile to produce acceptable acceleration forces. The basic tenets of this method have been described by Johnson.[1] This method can be applied as soon as the displacement diagram or table is prepared.

An existing cam may also be analyzed and modi-

[1]References are tabulated at end of article.

Table 1—Velocity and Acceleration Differences

Cam Angle θ (deg)	Displacement h (in.)	Velocity Number v	Acceleration Number a
0	0.00		
		0.05	0.05
1	0.05		
		0.13	0.08
2	0.18		
		0.14	0.01
3	0.32		
		0.20	0.06
4	0.52		
		0.24	0.04
5	0.76		

fied by this method. First, obtain the displacement diagram. If designed to operate a linear follower, the cam is mounted on a dividing head, and turned successively through 1 or 2-deg intervals. The change in radius is measured by a dial indicator. If the cam operates a follower on a swinging arm, the displacements must either be measured within the machine, or a full-size kinematic model must be used. Careful measurement is essential since the velocity errors will be twice, and the acceleration errors four times, any error in the displacement readings.

Procedure: Use a tabular arrangement as in Table 1. In the first column, record cam rotation in uniform increments of convenient size, for example, 1 deg. In the second column, enter the corresponding displacements h, the height above an arbitrary reference level. In the third column, enter the differences of the successive displacements. These differences, v, are a measure of the velocity of the follower. In the fourth column, enter the second differences, a, (differences of the values of the numbers in the third column) which are a measure of the acceleration of the follower.

True dimensions for v and a can easily be determined: Actual velocity $v_{act} = v/\delta\theta$ in. per deg or $v\,(6\,N/\delta\theta)$ in. per sec, where $\delta\theta$ = increment of cam rotation, deg, and N = cam speed, rpm. Similarly, $a_{act} = a/(\delta\theta)^2$ in. per deg^2 or $a\,(6\,N/\delta\theta)^2$ in. per sec^2.

The cam must rotate at a constant angular velocity for this procedure to be valid. Table 1 shows that excessive fluctuations may occur in the acceleration values even though the displacement curve seems smooth and the velocity is continuously increasing. However, direct revision of the acceleration curve is not satisfactory. For instance, consider increasing the third acceleration value from 0.01 to 0.07 alone. The velocity between 2 and 3 deg will then be 0.20 in.; the one between 3 deg and 4 deg becomes 0.26; the next 0.30; and all subsequent velocity terms will be increased by 0.26. Next, observe the effect of this upon the displacement. The displacement at 3 deg is increased 0.06 in. At 4 deg it is raised 0.12; the next 0.18; and the next 0.24.

This one change in the acceleration causes a runaway process in the displacements. The new displacements rapidly diverge from the originals which often should be preserved with as little change as possible. Other wild guesses can be made, but it becomes difficult to know whether improvements are being made. Instead, it is preferable to apply changes to the accelerations that produce only a limited number of changes in the displacement series.

"Standard" Change Patterns: Fig. 1 to 11 show a representative number of self-contained blocks of changes, or operations, that may be applied to the displacement, velocity, and acceleration numbers. The numbers in these blocks, or any multiple of them, can be added or subtracted, as indicated, from any adjacent group of numbers in the table of displacements with their first and second differences, without changes in any other numbers in the table.

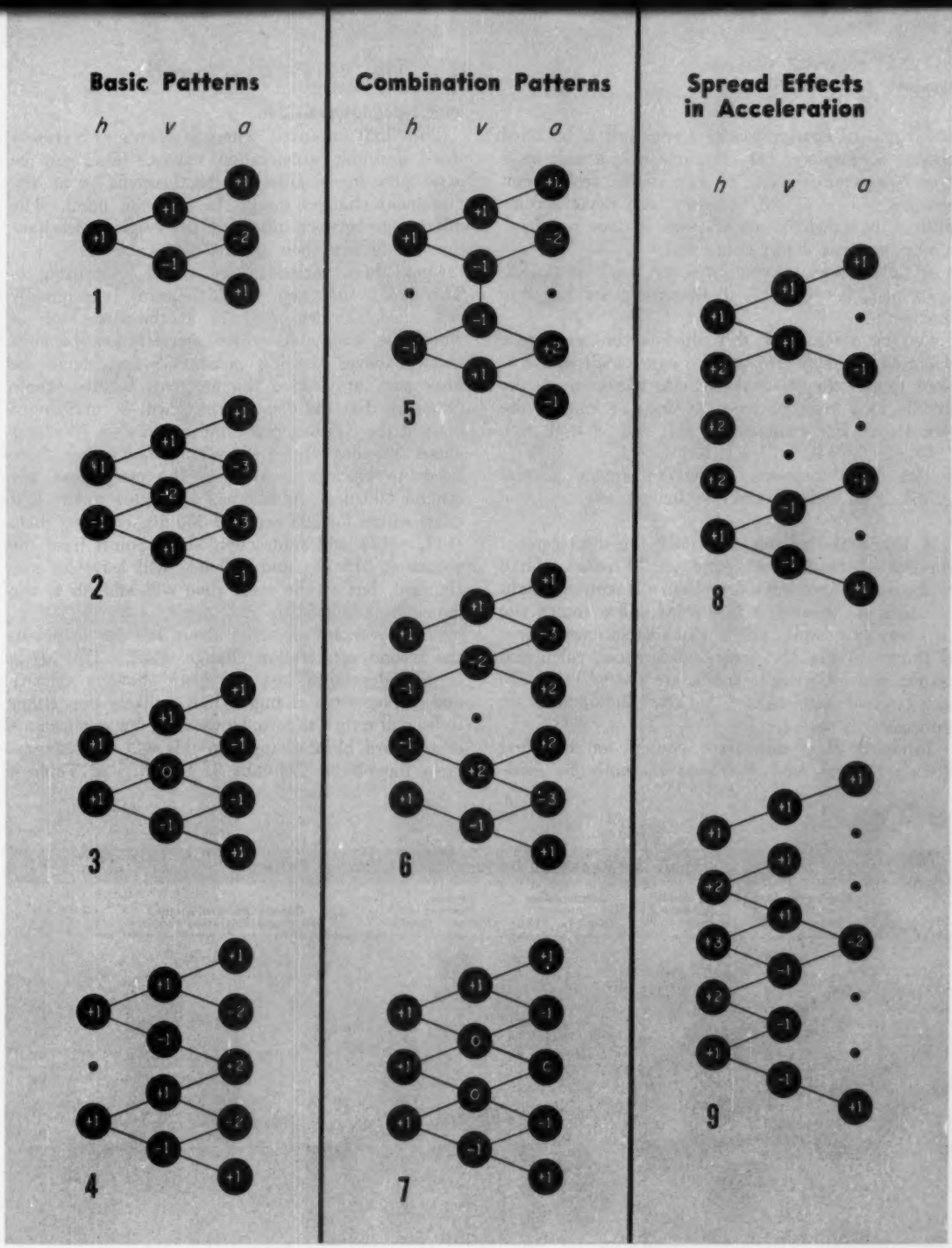
The first seven types are basic. Fig. 8 and 9 have a greater effect on the displacements than on the accelerations. These are useful in bringing the displacements back toward original values, if acceleration changes have caused too great a deviation. Fig. 10 and 11 show two possible operations that are specially designed to be heavier numerically on one side.

Finally, there are the "nonstop" operations shown in Fig. 12 to 14. Any of these may be inverted with slight changes. Fig. 15 is the inverse of Fig. 13. Such an operation as this may be used to stop a run. Other operational blocks can be made by combining any of the blocks shown.

Table 2 shows the follower displacement for each increment of cam rotation, for part of a displacement curve. Sample applications of several of the blocks are shown, along with the resulting smoother acceleration values. The smoothness of the acceleration changes can be evaluated by taking

Table 2—Typical Smoothing of Pulse

Displacement (in.) Original	Final	Velocity Number Original	Final	Acceleration Number Original	Final	Pulse Number Original	Final	Change Pattern Applied
1.00				−8				
		16				+1		
1.16				−7				Fig. 3
		9				+4	+3	
1.25				−3	−4			−1
		6	5			+2	+4	
1.31	1.30			−1	0			Fig. 1 +1
		5	5			+2	+3	
1.36	1.35			+1	+3			+1 +1
		6	8			+8	+3	
1.42	1.43			+9	+6			−2 −1
		15	14			−3	+1	
1.57				+6	+7			+1
		21				−1	−2	
1.78				+5	+5			Fig. 1
		26				−2	−1	
2.04				+3	+4			+1
		29	30			+2	−1	
2.33	2.34			+5	+3			−2
		34	33			−6	−3	
2.67				−1	0			+1
		33				−2	−3	
3.00				−3				
		30				+1		
3.30				−2				
		28						



the differences of the acceleration values. These quantities are identified as *pulse* or *jerk*.

Table 3 is a similar example. However, it requires the use of several more operation blocks to obtain the desired acceleration values.

Acceleration vs. Displacement: If, over a range of numbers, the displacement starts with a dwell at zero height (a dwell involves at least three consecutive zeroes), leaves it, but then later returns to a dwell at zero, so that there are n numbers between the two dwell zeroes, then

Theorem 1: The sum of all acceleration numbers, of which there will be $(n + 2)$, will always be zero.

Theorem 2: The sum of all velocity numbers, of which there will be $(n + 1)$, will be zero.

Furthermore, if the displacement varies from a dwell zero to any subsequent zero (dwell or transitory), then,

Theorem 3: If the acceleration numbers be regarded as transverse forces loading a beam, the moment of these loads about the point of zero displacement will be zero.

These three theorems show that only certain gen-

eral types of change blocks accomplish a bounded change in displacement. For instance, a half-wave type correction, such as one with acceleration changes +1, +3, +5, +3, +1, can never accomplish a bounded variation, since it does not have a zero moment about either end.

A full sine-wave type correction, such as 0, +7, +10, +7, 0, −7, −7, 0, likewise never has zero moment.

On the other hand, three half-waves can have a balanced moment, but for the sum of all accelerations to be zero (to conform with Theorem 1), the middle loop must be twice as deep or long as the side loops. For example, 0, +1, +2, +2, 0, −3, −4, −3, 0, +2, +2, +1, 0.

The three theorems, therefore, provide general guidance as well as absolute limitations.

A Practical Example: Consider the displacement curve of an actual experimental cam. The second half of the motion requires a drop from a maximum height of 0.526 in., through a low point and a return rise part way to a dwell. The original displacement curve is shown in Fig 16. Second differences, calculated on the basis of 5-deg intervals, are plotted in Fig. 16 as "original accelerations." The fluctuations are unnecessarily severe.

Intervals of 5 deg were chosen for the first attempt. Final analysis would normally be made with 1-deg intervals.

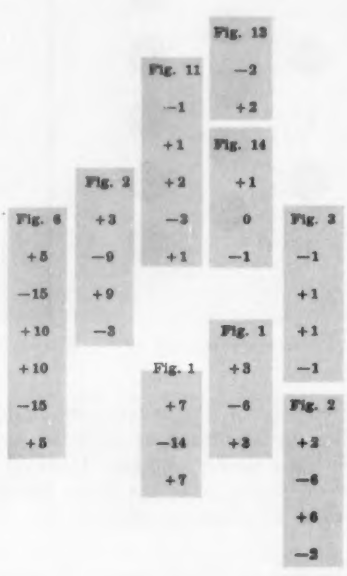
The "first improved" curve is drawn to represent more desirable acceleration values. This can be done quite freely, although the theorems for no displacement changes should be borne in mind. The differences between this and the original acceleration curve are then entered in Table 4.

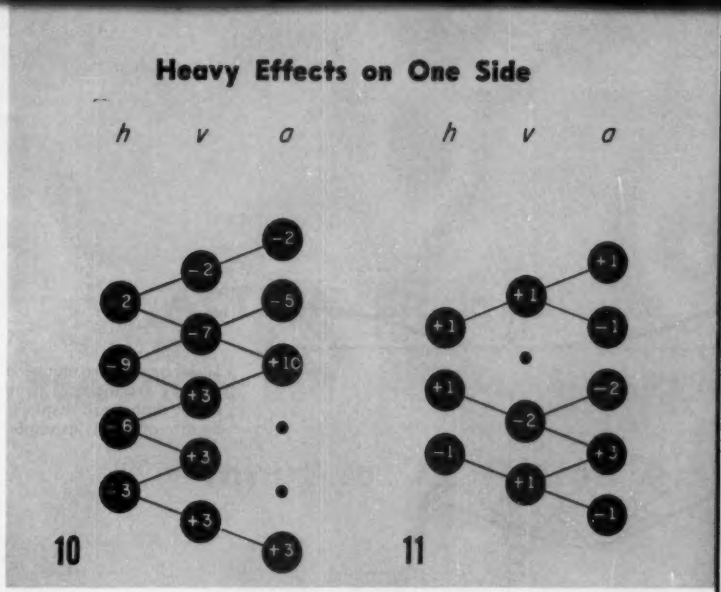
First, these variations are added. According to Theorem 1, their sum should be zero. It is actually +1 after 335 deg and −7 at the end, both of which are acceptable values. Acceleration moments about (above) the low point, 335 deg, should be near zero, as well as the moments for the whole range, so that the displacements will be unchanged both at the 335 deg point and at the end. Moments about 335 deg are −46, which shows that there needs to be less negative in the early part, say around 300 deg. Addition of six points to the first guess values for 295 deg and 300 deg (making them +11, −17) and subtraction of six points from the values at 315 deg and 320 deg will leave Σa unchanged, but at the same time will add 48 to the moment about 335 deg.

Next, evaluate moments about 360 deg to obtain the second acceleration change series. This series is then developed into the block showing velocity and displacement changes. It is unlikely that either series will return to zero. However, a few applications of standard block changes to this will soon accomplish the object. Columns 3, 4, and 5 of Table 4

Table 3—Repeated Applications of Change Patterns

Displacement (in.) Original	Final	Velocity Number Original	Final	Acceleration Number Original	Final	Pulse Number Original	Final	Change Pattern Applied (Showing acceleration numbers)
0.557	0.557							
		+11	+11					
0.568	0.568			+2	+2			
		13	13			+3	+1	
0.581	0.581			+5	+3			
		18	16			−4	−1	
0.599	0.597			+1	+2			
		19	18			+1	+1	
0.618	0.615			+2	+3			
		21	21			−2	0	
0.639	0.636			0	+3			
		21	24			+1	−2	
0.660	0.660			+1	+1			
		22	25			−6	−11	
0.682	0.685			−5	−10			
		17	15			−14	−14	
0.699	0.700			−19	−24			
		−2	−9			−18	−5	
0.697	0.691			−37	−29			
		−39	−38			0	+4	
0.658	0.653			−37	−25			
		−76	−63			+36	+10	
0.582	0.590			−1	−15			
		−77	−78			+10	+20	
0.505	0.512			+9	+5			
		−68	−73			−4	+1	
0.437	0.439			+5	+6			
		−63	−67			−4	+1	
0.374	0.372			+1	+7			
		−62	−60			+12	+4	
0.312	0.312			+13	+11			
		−49	−49			−1	+1	
0.263	0.263			+12	+12			
		−37	−37			+1	+1	
0.226	0.226			+13	+13			
		−24	−24					
0.202	0.202							





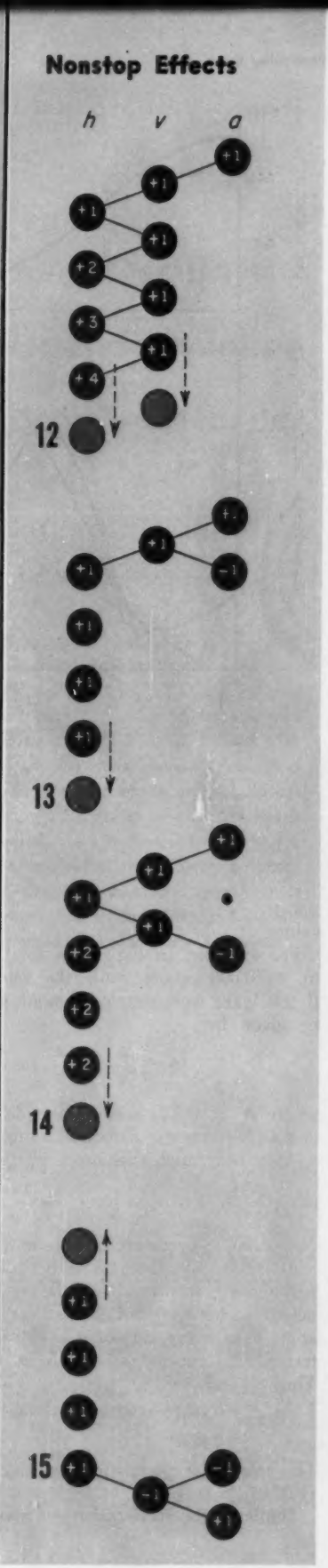
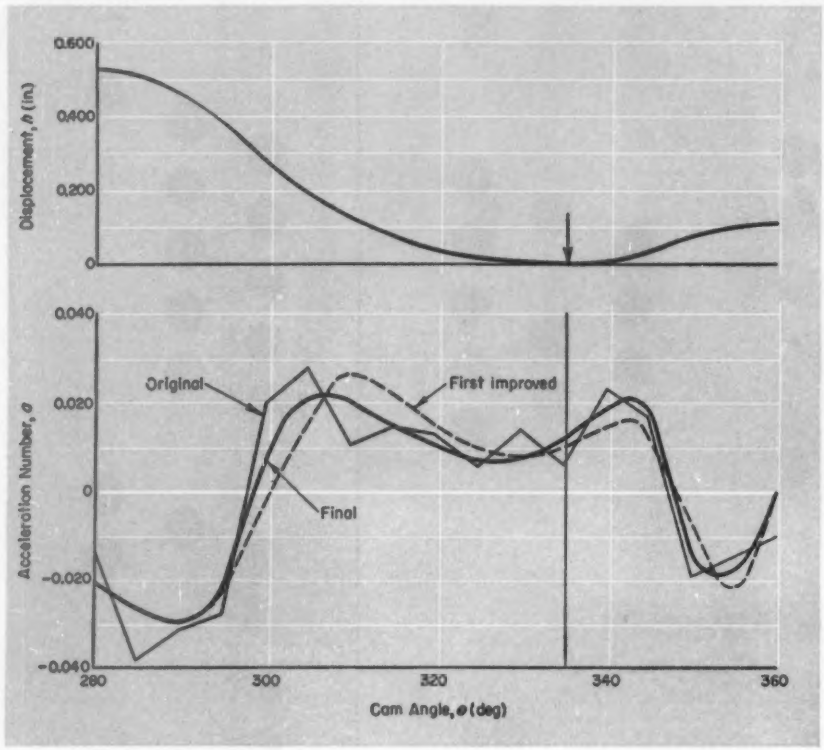


Table 4—Smoothing an Experimental Cam

Cam Angle (deg)	First Improved Acc. Number Change	Final Displ. Change	Final Vel. Number Change	Final Acc. Number Change
280	−8	0		−8
285	+11	−8	−8	+11
290	+1	−5	+3	+1
295	+5	−1	+4	+7
300	−23	+10	+11	−13
305	−12	+8	−2	−7
310	+16	+1	−7	+9
315	+7	+3	+2	0
320	+2	+5	+2	−2
325	+4	+5	0	+1
330	−6	+6	+1	−6
335	+6	+1	−5	+6
340	−8	+2	+1	−4
345	−5	−1	−3	+1
350	+12	−3	−2	+5
355	−7	0	+3	−3
360	0	0	0	0

show the changes that were finally applied to the original curves, resulting in those shown in Fig. 16.

Permissible values of numerical differences. In evolving a first and second difference table, the question arises as to the permissible magnitude of the velocity and acceleration numbers. The late Mr. Guy J. Talbourdet, of the United Shoe Machinery Corporation's Research Department, made the excellent suggestion that the values corresponding to simple-harmonic motion should be determined. Then the actual velocity and upward acceleration values should be held less than 50 per cent over these simple-harmonic values and downward accelerations should be held below the simple-harmonic



16

Improved acceleration values resulting from slight changes in displacements of cam example.

values.

For example, in Fig. 16, a total fall from 0.526 in. to 0.000 occurs while the cam turns 55 deg. If this wave were simple-harmonic motion, it would be given by

$$h = \frac{A}{2} + \frac{A}{2}\cos\phi$$

where $A = 0.526$ and ϕ (the displacement angle of simple-harmonic motion) changes 180 deg while θ (the cam angle) changes 55 deg. Thus,

$$h = 0.263\left(1 + \cos\frac{180}{55}\theta\right)$$

Now, simple-harmonic motion has a maximum velocity at $\phi = 90$ deg. The first-difference number representing this velocity will be the difference in height h, between points that are $2\frac{1}{2}$ deg of cam angle θ to either side of $\phi = 90$ deg. A 5-deg interval of θ means (180/55)5 or 16.36 deg in ϕ. Thus,

$$v_{max} = 0.263[\cos(90 + 8.18) - \cos(90 - 8.18)]$$
$$= 0.0749$$

The maximum permissible velocity number = 1.5 (0.0749) = 0.1123.

Similarly, the acceleration is a maximum at $\phi = 0$, and numerically appears as the difference of two velocities—one before and one after $\phi = 0$.

$$a_{max} = (h_{16.36} - h_0) - (h_0 - h_{-16.36})$$

But with simple-harmonic motion each of these differences, which are velocity values, are numerically equal and of opposite sign:

$$a_{max} = 2(h_{16.36} - h_0)$$
$$= 0.526(\cos 16.36 - 1)$$
$$= -0.0213$$

Permissible maximum acceleration numbers are therefore +0.0320 and −0.0213 by Talbourdet's criterion.

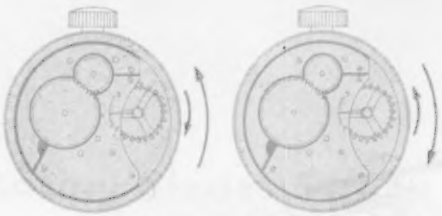
Fig. 16 shows that a maximum negative acceleration of 0.030 in. had to be allowed, since the shape of the displacement curve could not be greatly altered.

ACKNOWLEDGEMENT

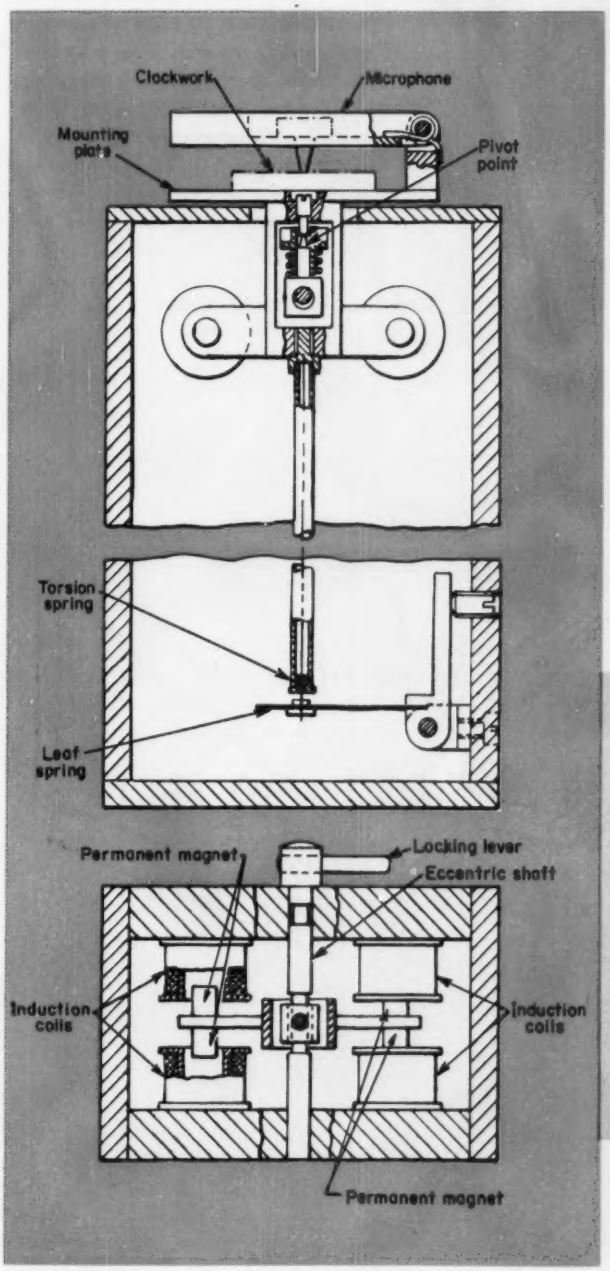
The author wishes to thank the United Shoe Machinery Corporation's Research Department, under whose auspices this study was first made, for permission to publish this material.

REFERENCES

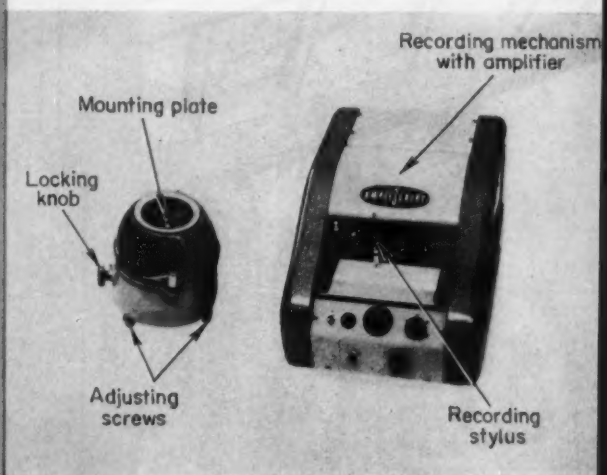
1. R. C. Johnson—Four articles in MACHINE DESIGN: "Cam Design," November, 1955, pp. 195-204; "Cam Profiles," December 13, 1956, pp. 129-132; "Cam Dynamics," February 7, 1957, pp. 105-108; "Cam Design," November 14, 1957, pp. 159-161.

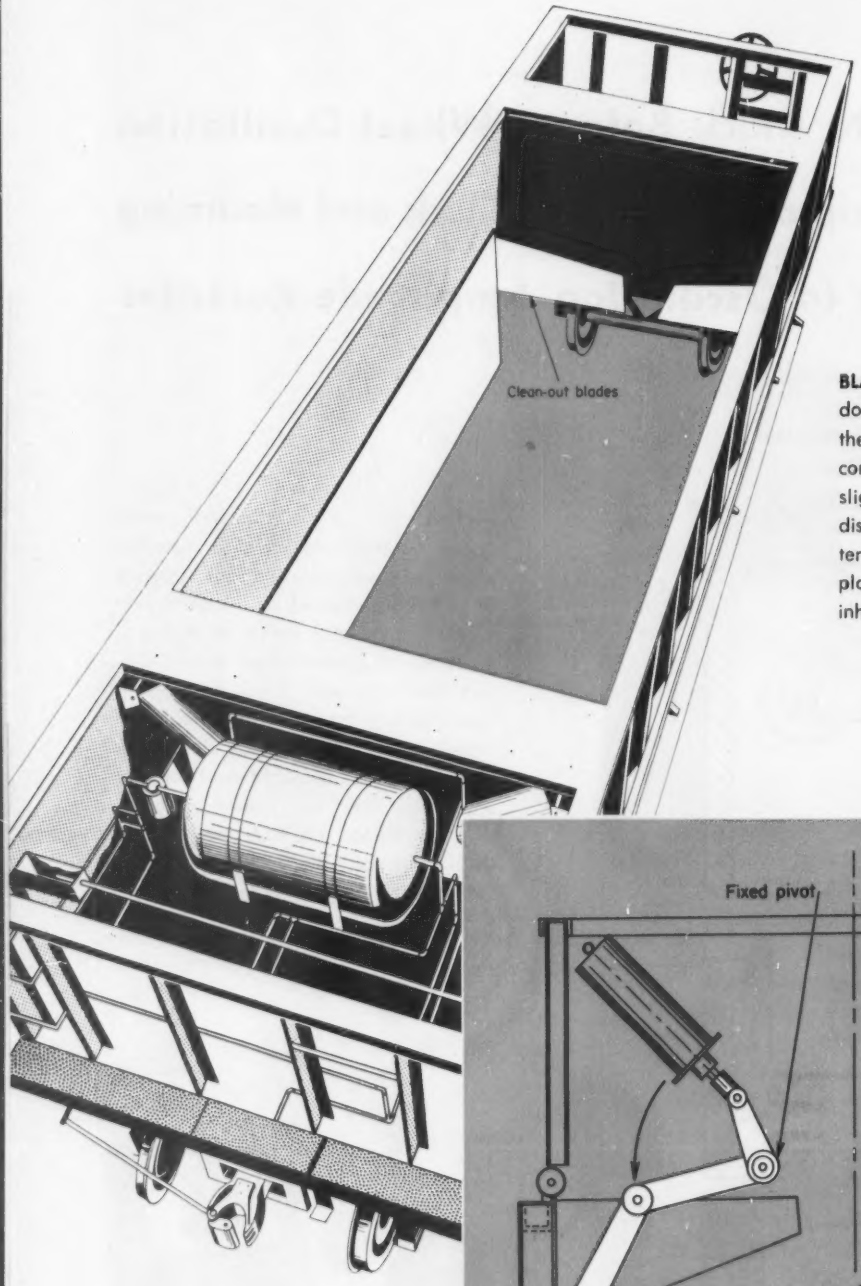


ACTION: Clock Balance Wheel Oscillation + REACTION: Reciprocal Motion of Clock and Mounting = Input to Oscillation Amplitude Recorder

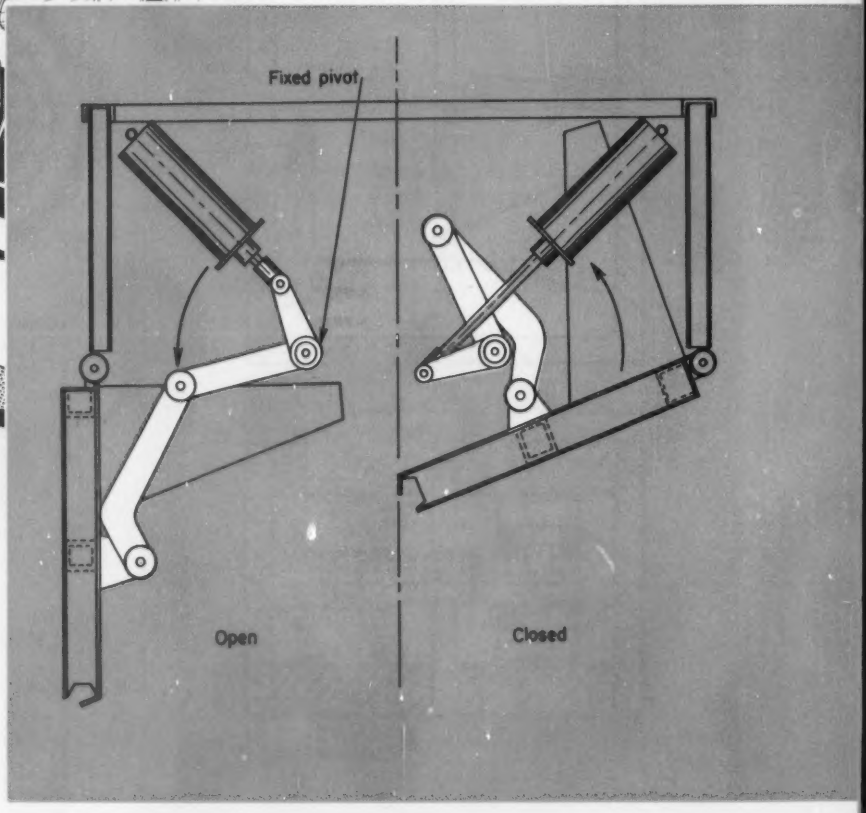


INERTIA from a clock balance wheel causes reciprocal motion of a mounting plate and permanent magnets fastened to it. Voltage induced by the permanent magnets in induction coils is a function of amplitude of balance-wheel motion. Current from the coils drives a recording stylus for a permanent record of balance-wheel motion. The mounting clamp is a microphone used to record the clock rate on another chart (not shown). Balance-wheel oscillation amplitude recorder is a development of Institute Dr-Inge Reinhard Straumann AG, Waldenburg, Switzerland.



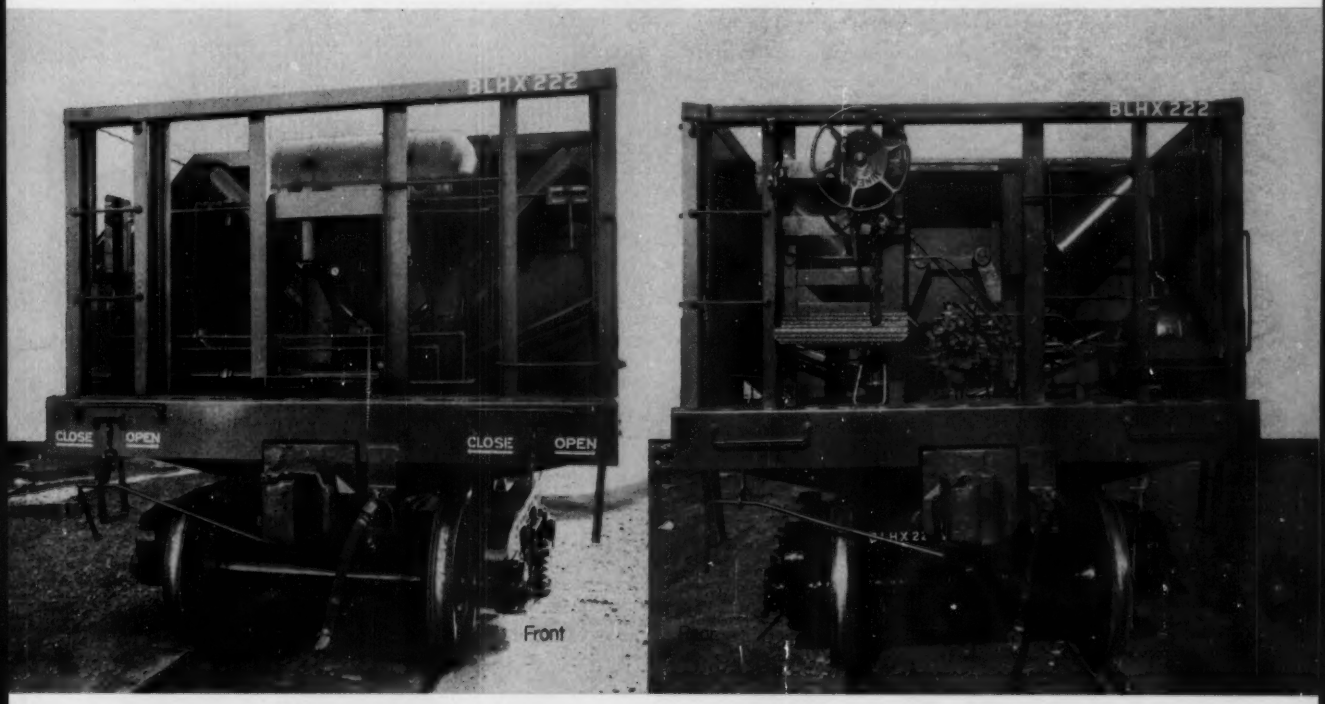


BLADES WELDED TO ENDS of swinging doors scrape the ends of an ore car as the doors open, dislodging sticky ore concentrate. Sides of the car slope slightly outward toward the bottom to discourage the buildup of sticky material along the sides. Eponfumaric plastic coating on interior of car also inhibits sticking of ore concentrate.

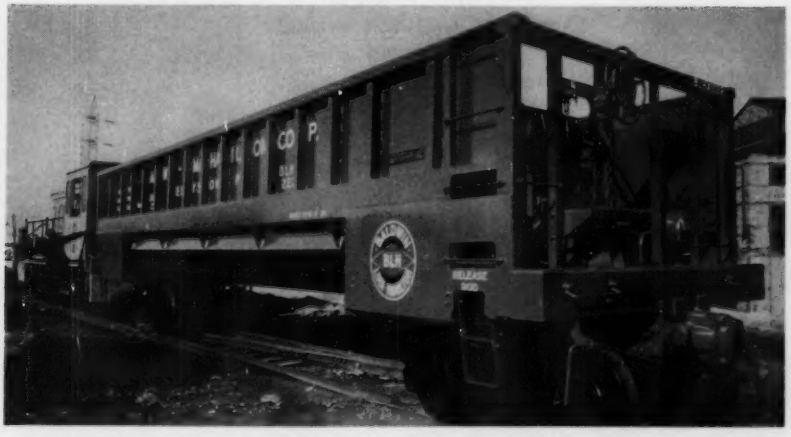


TOGGLE LEVER SYSTEM to operate bottom-dump doors is actuated by four double-acting pneumatic pistons. Over-center lock position on each toggle mechanism holds doors firmly when completely closed.

Rotating Blades Scrape Off Sticky Contents In Newly Designed Bottom-Dump Ore Car



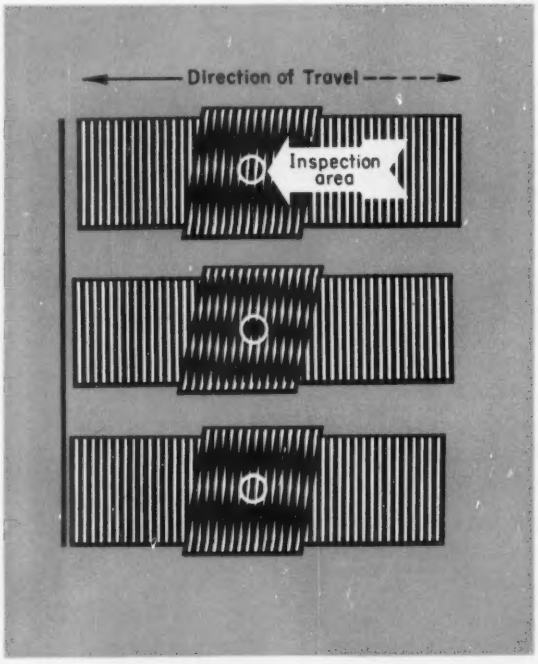
ENOUGH AIR TO OPERATE doors once is stored in 30-in.-diam by 60-in.-long tank charged at 90 psi. Normally, the train locomotive supplies air pressure. A spring-loaded pin (not visible) drops into a notch in the piston rod when doors are closed to guard against accidental opening when air pressure is off. Air pressure pushes the pin out before actuating the cylinder.



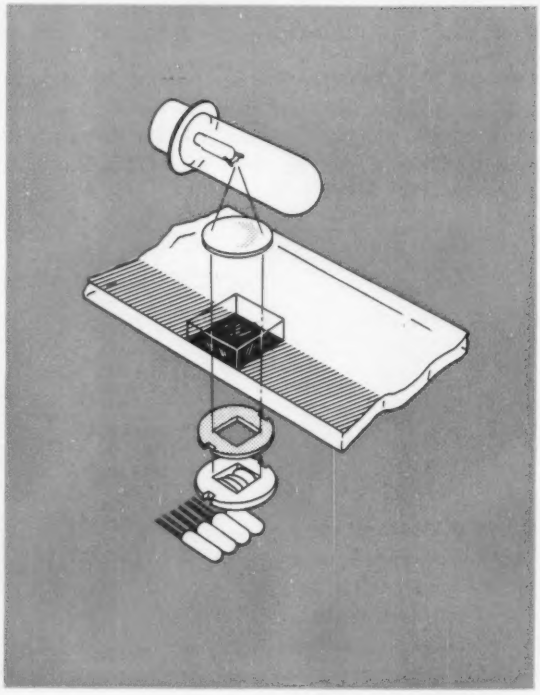
QUICK DISPOSAL of sticky cargos is achieved by new bottom-dump ore car designed by Eddystone Div., Baldwin - Lima - Hamilton Corp., Philadelphia.

Moire Fringe Bands Measure

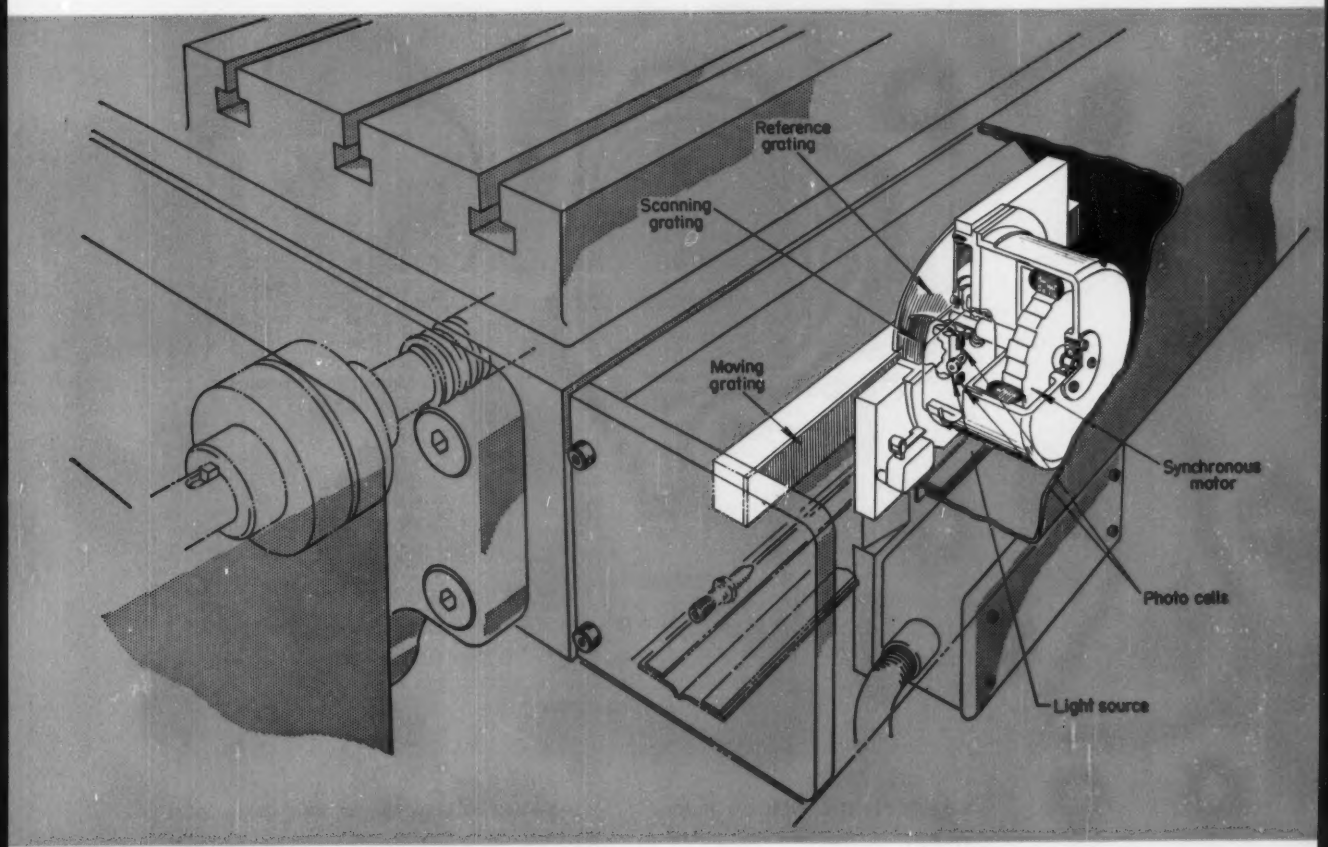
PRECISION INSPECTION is done with a machine that measures by counting moire fringe bands as one grating moves across another. By setting the moving grating at a slight angle with respect to the stationary grating, the developers have achieved a relatively coarse band spacing compared with the fine grates that are being moved. A photosensitive reader transfers information to a counter which translates the number of grid spaces crossed into a linear measure. Standard grid rulings of 6350 lines per inch can be used to obtain an accuracy of 0.00004 in. Loss or damage of a single grating line does not impair accuracy.

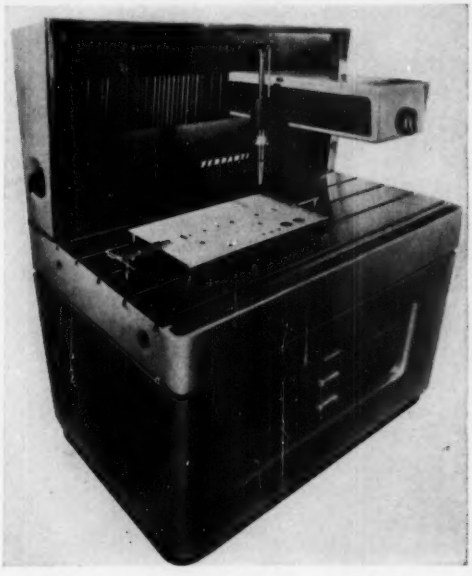


EACH PASSING MOIRE FRINGE BAND stimulates a pulse from the optical unit which is recorded in the digital counter. The instantly reversible counter "measures" small environmental vibrations in both directions up to the maximum counting rate. Thus, effects of low-frequency vibration are cancelled out. Small amount of hysteresis (1/20 grating pitch) is introduced into the pulse to insure that vibrations above the counting rate do not affect the count.



Minute Increments of Linear Motion

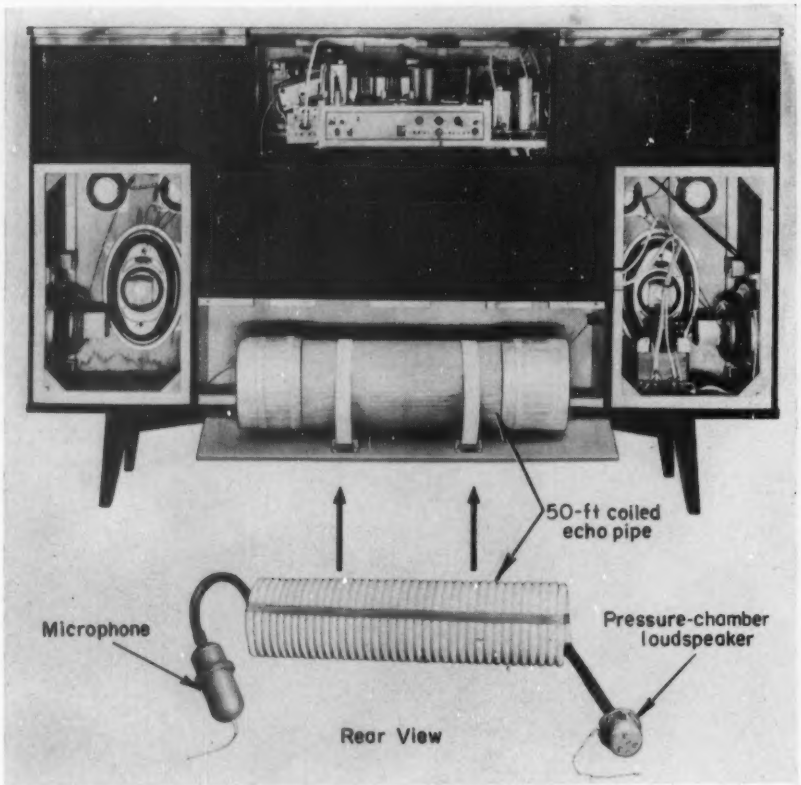




SPIRAL GRATING is used in a more complicated application of the moire fringe principle. Here the problem is to check on the rate of feed in a machine. The spiral rotational speed is controlled by a 104-cps reference signal through a synchronous motor. When the table is stationary, the photocell output is 104 cps. Movement of the table and its grating in one direction increases the frequency of the signal. Movement in the opposite direction reduces the frequency of the signal. Errors in the main signal generated by slight eccentricities of the spiral are cancelled out by similar shifts in signal from a non-moving reference grating.

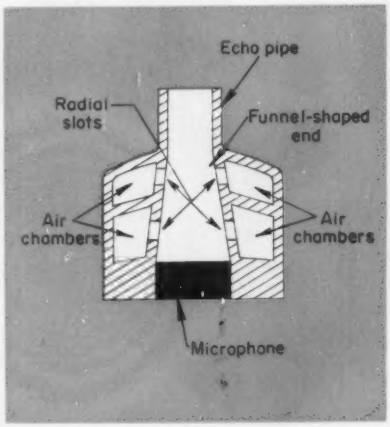
Co-ordinate inspection machine using the moire fringe principle to inspect parts was developed by Ferranti Electric Inc., Hempstead, N. Y.

Plastic Pipe Delays Sound

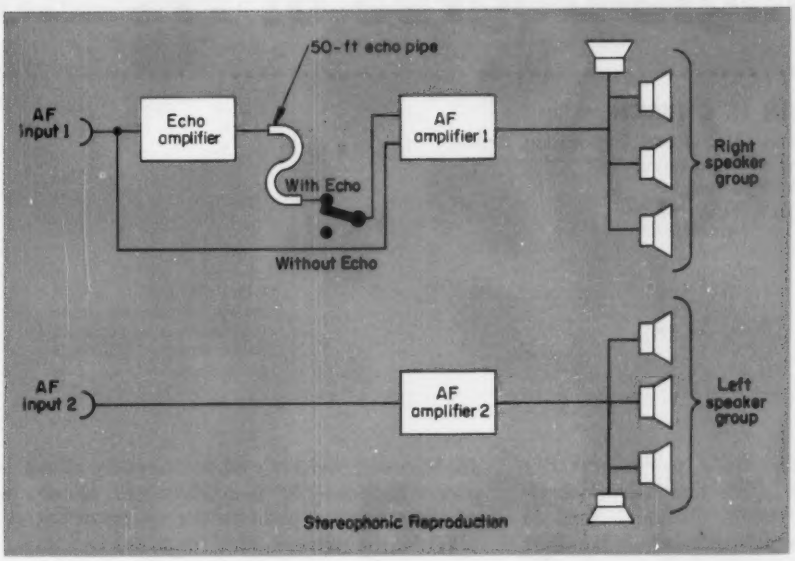


COILED PLASTIC PIPE, 50 ft long, located in the rear of a stereo phonograph, serves as echo chamber to produce a 50 msec delay similar to that of a large concert hall. Part of the audio-frequency signal is fed to an echo amplifier, then delayed by the coiled pipe equipped with a pressure-chamber speaker at the transmitting end and an acoustically shielded microphone at the receiving end. Foam rubber provides acoustic insulation. The delayed signal is fed to amplifier 1.

FREQUENCY RANGE OF ECHO CIRCUIT is 6000 cps. This response is possible through an acoustic filter incorporated in the echo-pipe microphone end. The pipe widens into a funnel-shaped section which is surrounded by a number of air chambers connected to the pipe by a corresponding number of radial slots. Chambers and slots suppress undesirable peaks in the frequency response curve.



For Mechanically Produced Echo



FOR STEREOPHONIC REPRODUCTION without echo, audio-frequency inputs 1 and 2 connect directly, but separately, with amplifiers 1 and 2 which power right and left speaker group respectively. Through coiled pipe, echo can be added to channel 1 only. A voltage divider (not shown) between echo-pipe microphone and amplifier 1 permits volume control of delayed audio signal.

Combination radio and phonograph using echo chamber design was developed by Blaupunkt-Werke GmbH, Hildesheim, Germany.

Single-Degree-of-Freedom

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MOBILITY and impedance techniques[1] can be powerful aids in the analysis of vibrating mechanical systems. Although they do not supplant conventional methods of handling vibration problems, these techniques do offer decided advantages in many situations.

A common but important problem in vibration analysis is to find the motion response of a linear system to a harmonic force under steady-state conditions. Three general methods of dealing with such problems will be considered here:

1. Classical
2. Component mobility
3. Normal-mode mobility

In the well-known classical method, differential equations are written for the forces or torques acting on each mass. These equations are then solved for response. This method will be used here only to relate results to the other two methods.

The component-mobility method[2,3,4] uses mobilities and impedances to find motion response of each component (spring, mass, or damper) in terms of displacement, velocity, or acceleration. Each component response is then combined to determine response at some point in the system.

With the normal-mode mobility method, motion response at a point in the system is found in terms of normal modes of vibration of the system.[5,6] Response for each normal mode may then be added algebraically to find the resultant response of a point.

The first two methods tend to become quite involved for multimass systems, particularly if appreciable damping is present. However, a clear knowledge of them is helpful in understanding the basic concepts of response.

Application of these methods in the analysis of single-degree-of-freedom systems will be discussed in this article. Other common types of vibrating systems will be examined in succeeding articles.

Consider the conventional single-degree-of-freedom system shown in Fig. 4*a*. To illustrate application of the three methods of analysis in detail, response of this system will be determined as frequency of the impressed force, F, is varied. Numerical values have been assigned to system elements

[1]References are tabulated at end of article.

Table 3—Effect of Frequency Variation on Calculated Values for Single-Degree-of-Freedom System*

f (cps)	ω (rad per sec)	x_o (micro-inches)	ϕ (deg)	ψ (deg)	F_s (lb)	F_d (lb)	F_m (lb)	v_o (ips)	M_{VC} (microinches per lb-sec)	β	$1/\beta$	M_{DC} (microinches per lb)	M_{AC} (in. per lb-sec^2)
128	800	131	3	87	210	10.5	8.4	0.1048	524	0.2	5	0.655	0.419
576	3,600	425	49.8	40.2	680	153	550	1.53	7,650	0.9	1.11	2.123	27.57
640	4,000	500	90	0	800	200	800	2	10,000	1	1	2.5	40
704	4,400	371	127.4	−37.4	594	159	699	1.588	7,940	1.1	0.91	2.08	40.26
3,200	20,000	5.2	177	−87	8.4	10.5	210	0.1048	524	5	0.2	0.026	10.4

*Based on system in Fig. 4*a*; f_n = 637 cps.

Systems

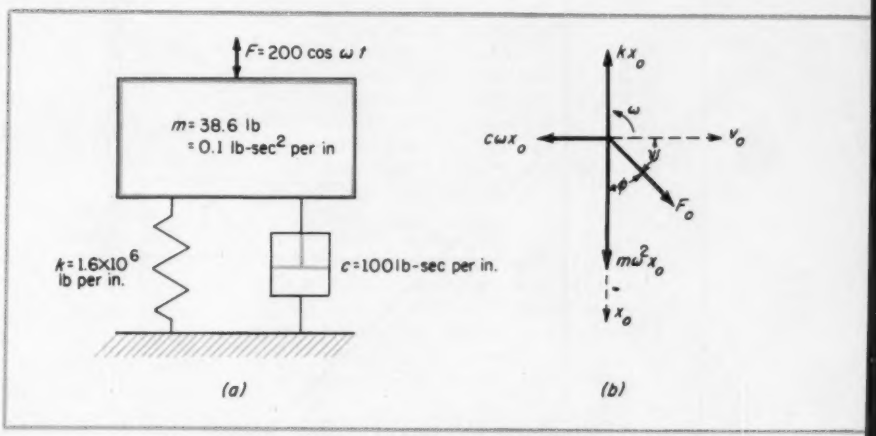

Fig. 4 — Typical single-degree-of-freedom system showing, *a*, conventional schematic representation and, *b*, corresponding vector diagram.

to aid visualization of the effect of frequency variation on system relationships. Response will be found first by conventional equations based on the classical method, and then by mobility and impedance concepts.[1]

Classical Method: The conventional vector diagram for the system in Fig. 4*a* is given in Fig. 4*b*. Basic relationships are:

$$x_o = \frac{F_o}{[(c\omega)^2 + (k - m\omega^2)^2]^{1/2}} \quad (22)$$

$$\tan \phi = \frac{c\omega}{k - m\omega^2} \quad (23)$$

$$\omega_n = \left(\frac{k}{m}\right)^{1/2} \quad (24)$$

$$c_c = 2m\omega_n = 2(km)^{1/2} \quad (25)$$

Numerical values assigned to the elements of the system in Fig. 4*a* include a relatively large amount of damping to make its effect more apparent. Substituting these values in Equations 22 through 25 gives

$$x_o = \frac{200}{[(100\omega)^2 + (1.6 \times 10^6 - 0.1\omega^2)^2]^{1/2}}$$

$$\tan \phi = \frac{100\,\omega}{1.6 \times 10^6 - 0.1\omega^2}$$

$$\omega_n = \left(\frac{1.6 \times 10^6}{0.1}\right)^{1/2} = 4000 \text{ rad per sec}$$

$$c_c = 2 \times 0.1 \times 4000 = 800$$

Also, ratio $c/c_c = 100/800 = 0.125$

Values of x_o and ϕ have been calculated for several values of frequency and are listed in Table 3, along with values of ψ, the phase angle by which F_o lags the v_o vector. Fig. 4*b* also shows that $\psi = 90 \text{ deg} - \phi$.

The various forces and their equations are: Spring force, $F_s = kx_o$; damper force, $F_d = c\omega x_o$; inertia force, $F_m = mx_o\omega^2$. Magnitudes of these forces have been calculated and are listed in Table 3.

Values of velocity amplitude, $v_o = x_o\omega$, and velocity mobility of the mass, $M_V = v_o/F_o$, are also given in this table. The values of velocity mobility are plotted against frequency on the mobility chart, Fig. 5.

Component-Mobility Method: Velocity mobilities of the three components in Fig. 4*a* can be calculated as a function of frequency with Equations 9, 10, and 11.[1] These mobilities are the straight, long-dashed lines on the log-log mobility chart, Fig. 5.

Before the combined velocity mobility of the system is found, the schematic diagram, Fig. 6, should be drawn. Since both the spring and dashpot are attached to the frame, they are shown grounded. Motion of the mass and the harmonic force are referred to the frame, so they are also grounded. Since all components have the same velocity, and the force impressed on the system equals the sum of the component forces, the action is in parallel. Then, combined velocity mobility as given by Equation 20[1] is:

$$M_{VC} = \frac{1}{Z_{Vd} + Z_{Vm} + Z_{Vs}} = \frac{1}{c + jm\omega - \frac{jk}{\omega}}$$

$$= \frac{j\omega}{cj\omega + k - m\omega^2} = \frac{j\omega(k - m\omega^2) + c\omega^2}{(k - m\omega^2)^2 + (c\omega)^2} \quad \ldots (26)$$

This equation is a complex number which can be represented as shown in Fig. 7. The modulus of

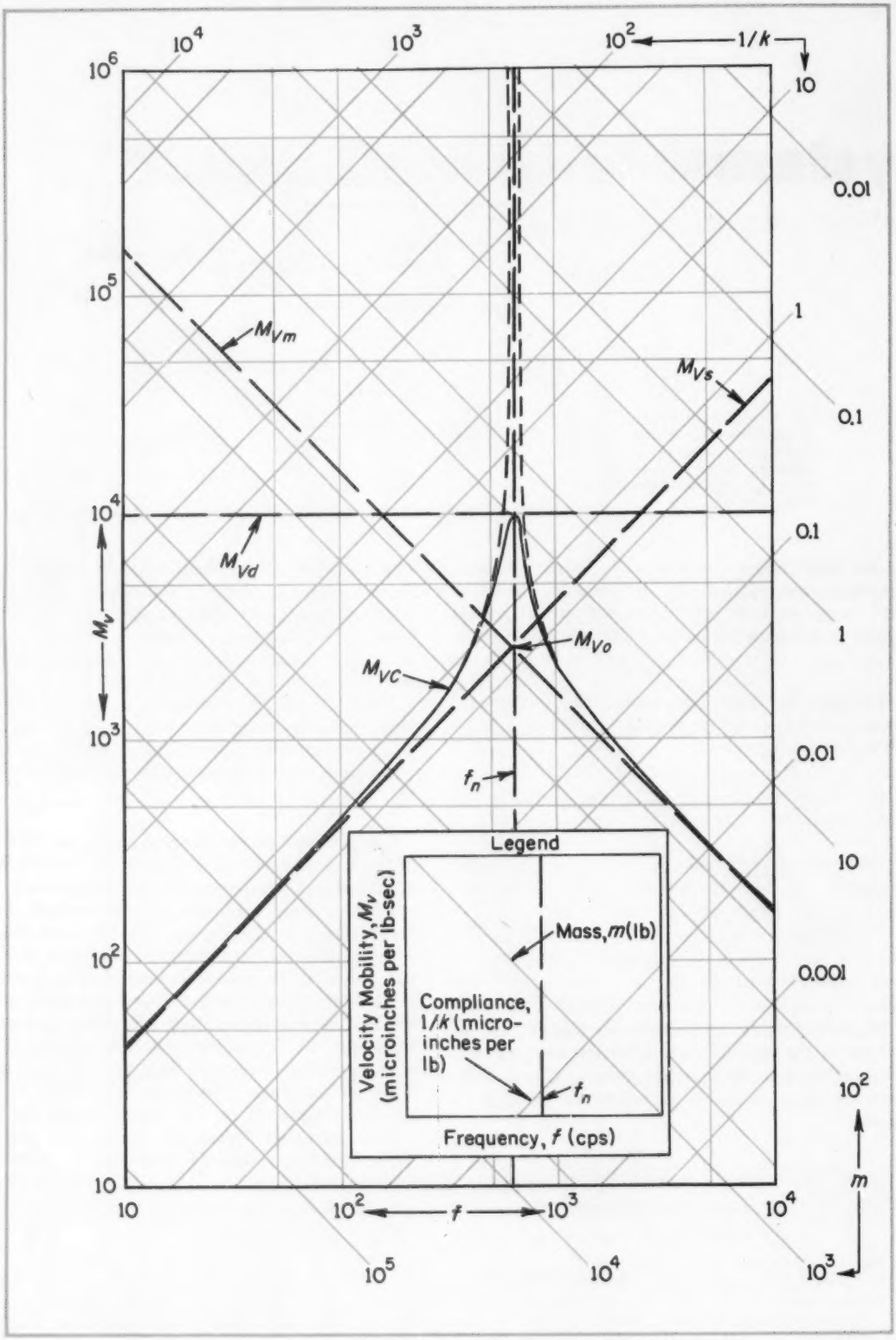

Fig. 5—Mobility plots for single-degree-of-freedom system shown in Fig. 4.

this number is found by taking the square root of the sum of the squares of the real and imaginary parts, or

$$|M_{VC}| = \left|\frac{v_o}{F_o}\right| = \frac{\omega}{[(c\omega)^2 + (k - m\omega^2)^2]^{1/2}} \quad (27)$$

which can be converted to the displacement basis of Equation 22 when both sides are divided by ω. Also, from Fig. 7,

$$\tan \psi = \frac{k - m\omega^2}{c\omega} \quad (28)$$

which is the reciprocal of tan ϕ, Equation 23.

Substituting the numerical values of the system elements, Fig. 4*a*, in Equations 27 and 28 gives the values of M_{VC} and ψ listed in Table 3.

Since $M_V = v_o/F_o$, or $F_o = v_o/M_V$, values of the various forces already calculated and listed in Table 3 can be checked with: $F_s = v_o/M_{Vs}$; $F_d = v_o/M_{Vd}$; $F_m = v_o/M_{Vm}$.

In Fig. 5 the combined velocity-mobility curve, M_{VC}, is asymptotic to the spring-mobility line at low impressed frequencies and to the mass-mobility line at high impressed frequencies. This indicates the predominance of the spring and mass forces in the low and high-frequency ranges. Thus, for impressed frequencies below the natural frequency the system is "spring-controlled". Phase angle ψ then lies between +90 and 0 deg. For frequencies above the natural frequency the system is "mass-controlled," and phase angle ψ lies between 0 and −90 deg. In Fig. 8, a plot of the forces exerted by the various components (Table 3) versus frequency substantiates the statements just made.

Resonance occurs when the combined velocity mobility has a zero imaginary part. Phase angle ψ is then zero, and the system is entirely controlled by the damper force. At that point the combined velocity-mobility curve is tangent to the damper-mobility line.

Note that the spring-force curve is similar to the

Nomenclature

c = Viscous damping factor, lb-sec per in.
d = Diameter, in.
F = Force, lb
f = Cyclic frequency, cps
G = Shear modulus, psi
J = Mass moment of inertia, in.-lb-sec^2
j = Imaginary operator
= $(-1)^{1/2}$
k = Spring gradient or rate, lb per in.
L = Length, in.
M_A = Acceleration mobility, in. per lb-sec^2
M_D = Displacement mobility, in. per lb
M_V = Velocity mobility, in. per lb-sec
m = Mass, lb-sec^2 per in.
Q = Amplification factor at resonance
T = Torque or moment, lb-in.
t = Time, sec
v = Velocity, in. per sec
x = Linear displacement, in.
Z_D = Displacement impedance, lb per in.
Z_V = Velocity impedance, lb-sec per in.
β = Ratio of impressed to natural frequency
δ = Logarithmic decrement
θ = Angular displacement, or slope, rad
$\dot{\theta}$ = Angular velocity, rad per sec
ϕ = Phase angle between displacement and force vectors, deg or rad
ψ = Phase angle between force and velocity vectors, deg or rad
ω = Circular or angular frequency, rad per sec

Subscripts

a = Point location in a system
b = Point location in a system
C = Combined; point location in a system
c = Critical
d = Damper
E = Point location in a system
i = Isolator
m = Mass
n = Natural or resonant
o = Amplitude or vector length; characteristic
s = Spring

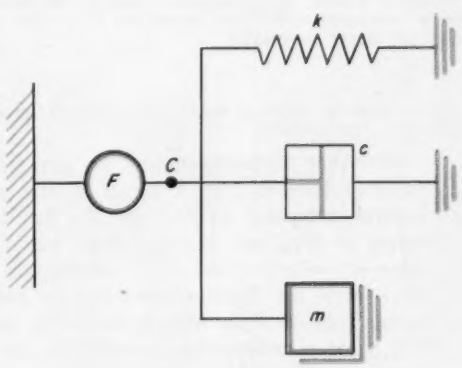

Fig. 6—Schematic mobility diagram for mechanical system in Fig. 4*a*.

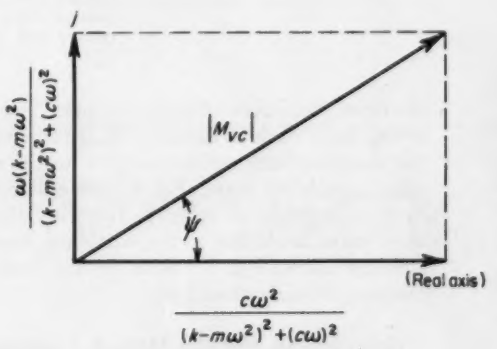

Fig. 7—Vector diagram for Equation 26 which contains both real and imaginary terms.

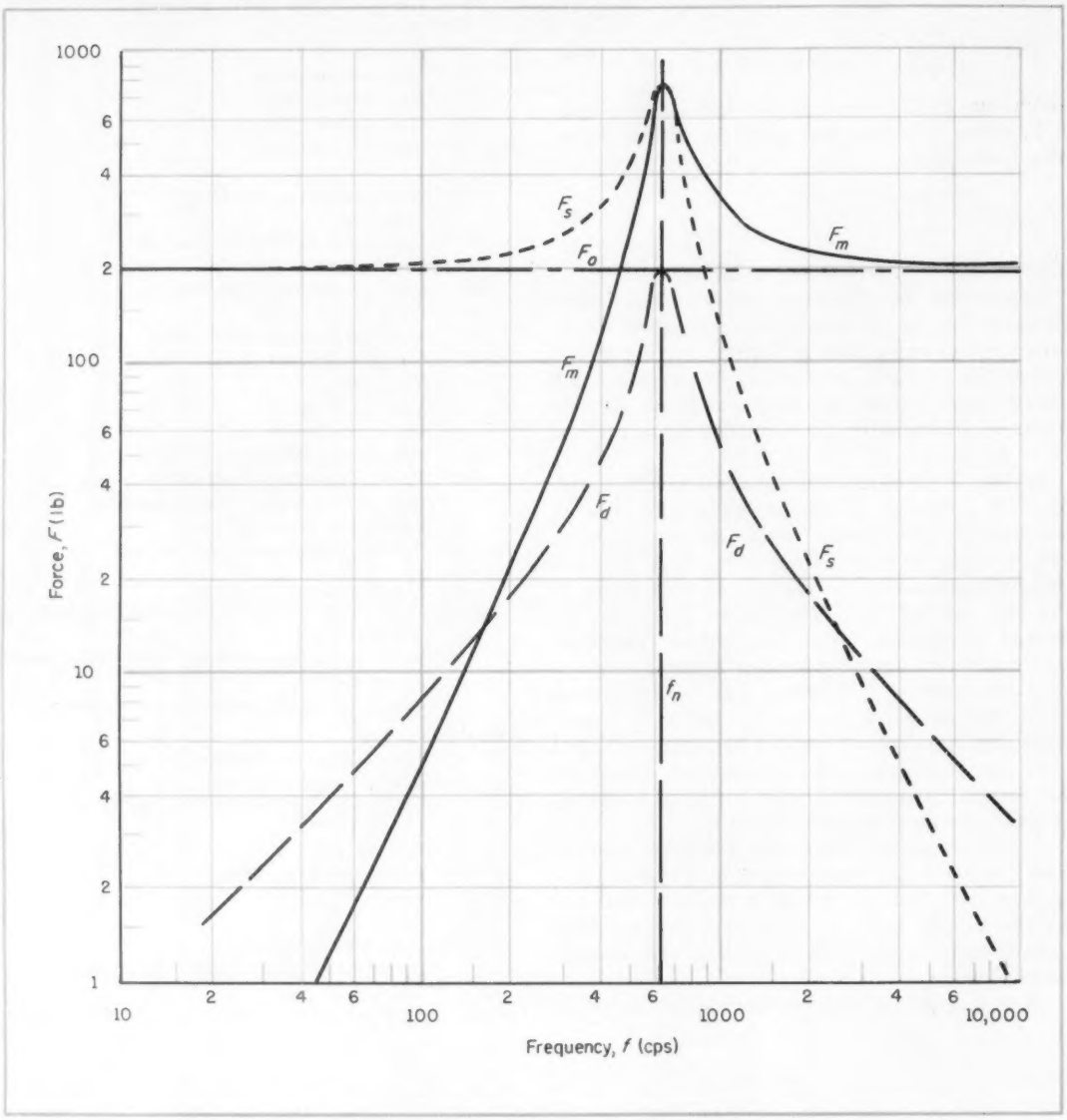

Fig. 8—Plot of component forces versus frequency for system in Fig. 4*a*. Vertical dashed line represents natural frequency f_n. Horizontal dashed line represents impressed force F_o. System is "spring-controlled" at frequencies below the natural frequency and "mass-controlled" at higher frequencies.

combined displacement-mobility curve, Fig. 3,[1] since spring force F_s is a function of displacement. Also, the damping-force curve is similar to the combined velocity-mobility curve, Fig. 3,[1] since damping force F_d is a function of velocity. Likewise, the inertia-force curve is similar to the combined acceleration-mobility curve, Fig. 3,[1] since inertia force F_m is a function of acceleration.

Normal-Mode Mobility Method: Usefulness of the normal-mode mobility method of vibration analysis is not apparent when applied to a system having a single degree of freedom. However, examination of Fig. 5 leads to certain conclusions that can be applied in solving more complicated problems by this method.[5,6]

Note that the intersection of the spring and mass-mobility lines of Fig. 5 occurs at the undamped natural frequency of 637 cps. At this frequency, values of M_{Vm} and M_{Vs} are equal but of opposite signs, or $j\omega/k - j/m\omega = 0$. Solving this equation for ω gives the familiar expression for natural frequency, $\omega_n^2 = k/m$. Magnitude of the mobility at this point of intersection is known as the "characteristic mobility," M_{Vo}.

Substituting the value of ω_n into the expression for either M_{Vs} or M_{Vm} and ignoring the j term, which merely indicates direction,

$$M_{Vo} = \frac{j\omega_n}{k} = \frac{j}{m\omega_n} = \frac{1}{(km)^{1/2}} \qquad (29)$$

or, using the numerical values previously assigned, Fig. 4*a*,

$$M_{Vo} = \frac{637 \times 2\pi}{1.6 \times 10^6} = \frac{1}{0.1 \times 637 \times 2\pi}$$

$$= 0.0025 \text{ in. per lb-sec}$$

One method of representing the amount of damping in a system is to use the amplification factor, Q, which is the ratio of combined mobility or response at resonance to characteristic mobility. From Fig. 5, then,

$$Q = \frac{M_{Vd}}{M_{Vo}} = \frac{1}{cM_{Vo}}$$

Substituting Equations 25 and 29 into this expression,

$$Q = \frac{1}{cM_{Vo}} = \frac{(km)^{1/2}}{c} = \frac{1}{2\left(\frac{c}{c_c}\right)} \qquad (30)$$

The numerical value of Q for the given system, Fig. 4*a*, is

$$Q = \frac{1}{cM_{Vo}} = \frac{1}{100(0.0025)} = 4$$

Equation 30 may be solved in terms of the logarithmic decrement, δ, by using the relationship,

$$\frac{c}{c_c} = \frac{\delta}{(4\pi^2 + \delta^2)^{1/2}}$$

From Equation 30, then,

$$Q = \frac{(4\pi^2 + \delta^2)^{1/2}}{2\delta} \qquad (31)$$

If δ is small compared to $4\pi^2$, Equation 31 reduces to

$$Q \approx \frac{\pi}{\delta} \qquad (32)$$

While the amplification factor for the system considered here is 4, Q generally has a value between 200 and 500 for a metal beam without external damping. For fabricated structures, the value of Q usually falls between 25 and 100. If the system has no damping, Q is infinite, as is the combined velocity mobility at resonance.

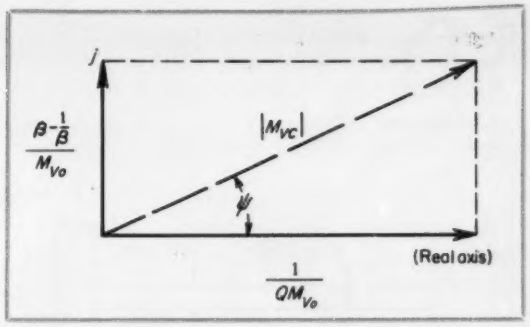

Fig. 9—Vector representation of Equation 33 for combined velocity mobility, M_{VC}.

Equation 26 can be converted into a form suitable for calculating mobilities on a normal-mode basis by inserting terms from Equations 29 and 30, and the term, $\beta = \omega/\omega_n = \omega/(k/m)^{1/2}$. Then,

$$M_{VC} = \frac{1}{c + j\left(m\omega - \frac{k}{\omega}\right)}$$

$$= \frac{1}{\frac{1}{M_{Vo}Q} + \frac{j}{M_{Vo}(km)^{1/2}}\left(m\omega - \frac{k}{\omega}\right)}$$

$$= \frac{M_{Vo}}{\frac{1}{Q} + j\left(\beta - \frac{1}{\beta}\right)} \qquad (33)$$

This relationship is shown in Fig. 9, from which

$$|M_{VC}| = \frac{M_{Vo}}{\left[\frac{1}{Q^2} + \left(\beta - \frac{1}{\beta}\right)^2\right]^{1/2}} \qquad (34)$$

Equation 34 indicates that the M_{VC} curve shape depends only on the value of Q. Results obtained with this equation are symmetrical about ω_n in terms of β and $1/\beta$ as shown by the values listed in Table 3. Hence, the log-log plot of $|M_{VC}|$ in Fig. 5 is symmetrical about the resonant frequency $\omega = \omega_n$, or $\beta = 1$.

The preceding facts suggest a simple method of drawing the combined velocity-mobility curve for any set of component numerical values as long as

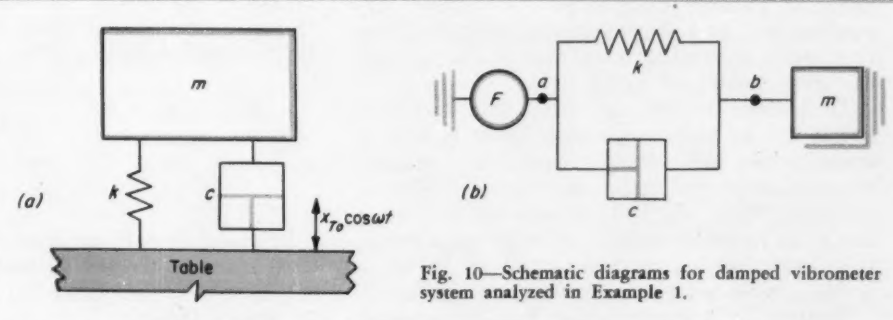

Fig. 10—Schematic diagrams for damped vibrometer system analyzed in Example 1.

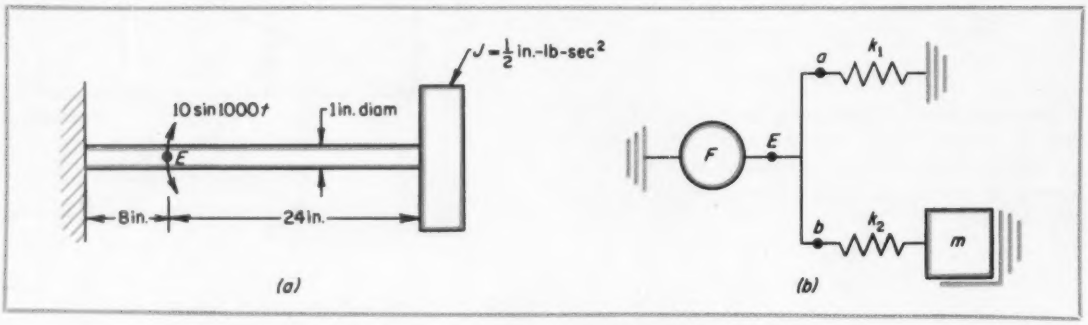

Fig. 11—Schematic diagrams of shaft-disc assembly analyzed in Example 2.

relative amount of damping and scale of the diagram do not change. Component mobility parameters can be drawn, without calculation, parallel to the lines on the mobility chart. Then, a template that has the combined curve shape for a given damping factor, or Q value, in accordance with the denominator of Equation 34, can be used. This template would have the four component parameters drawn on it. Locating any two of the four parameters on the chart locates the template position, and the combined curve can then be traced.

In Fig. 8 or Table 3, note that magnitude of the damping force becomes significant only in the vicinity of the resonant frequency. Hence, the combined curve shape is changed appreciably only near the natural frequency of the system as the amount of damping is altered. If there is no damping, velocity mobility or response becomes infinite at resonance as shown by the short-dashed curve of Fig. 5.

Application of Methods: Although velocity mobilities have been used to illustrate the component mobility and normal-mode mobility methods, discussion could have been developed on a displacement or acceleration basis. Combined mobility curves would then have the shapes shown in Fig. 3.[1]

If response is required only at a particular frequency, the complete response spectrum need not be drawn. Equations previously found can be solved for response at the frequency desired.

The system shown in Fig. 4 has all components acting in parallel. Many other arrangements are possible, even in a single-degree-of-freedom system. Frequently, solution involves use of the concept of transfer mobility or impedance.

To indicate transfer functions here, two subscripts will be used on the mobility or impedance symbols. The first subscript locates the point of response while the second identifies the point of excitation. Thus, M_{ab} indicates response at point a due to an excitation at point b. When other identifying subscripts are used, notation will be $M_{D,ab}$ or $M_{D,aa}$ when point a is also the point of response.

EXAMPLE 1: A system having mass m supported on an isolator with spring gradient k and damping factor c is placed on a shake table, Fig. 10a. The table vibrates harmonically with a motion, $x_T = x_{T0} \cos \omega t$. Find the expression for motion of the mass by means of displacement mobilities and impedances.

This system is the standard damped vibrometer arrangement and can be readily analyzed by the classical method. The problem is included here because it introduces the concept of transfer functions and clarifies the procedure of handling motion problems by mobility methods.

First step is to draw the schematic diagram, or equivalent circuit, Fig. 10b. Components of the isolator act in parallel, and the isolator acts in series with the mass. Two points of particular interest in the system are points a and b, Fig. 10b.

Since the excitation is a motion rather than a force, a method of attack must be established next. If response at point a caused by an imaginary force F_a applied at a is found, the value of the driving-point mobility, $M_{D,\,aa} = x_{ao}/F_{ao}$. And, if response at b, or at the mass, caused by the same imaginary force, F_a, is found, the value of the transfer mobility, $M_{D,\,ba} = x_{bo}/F_{ao}$. The ratio of these two mobilities is

$$\frac{M_{D,\,ba}}{M_{D,\,aa}} = \frac{x_{bo}}{F_{ao}} \frac{F_{ao}}{x_{ao}} = \frac{x_{bo}}{x_{ao}} \qquad (35)$$

Next step is to find the properties of the isolator. From Equation 21,[1] impedance of the isolator, $Z_{Di} = Z_{Ds} + Z_{Dd} = k + j\omega c$. Mobility of the isolator, $M_{Di} = 1/(k + j\omega c)$. Because the mass and isolator act in series, Equation 18[1] gives

$$M_{D,\,aa} = M_{Di} + M_{Dm} = \frac{1}{k + j\omega c} - \frac{1}{m\omega^2}$$

$$= \frac{m\omega^2 - k - j\omega c}{m\omega^2(k + j\omega c)}$$

Impressed force F_a acting at m is the same as the force acting on the isolator since they are in series.

Displacement amplitude $x_{bo} = M_{Dm}F_{ao} = -F_{ao}/(m\omega^2)$. Hence,

$$M_{D,ba} = \frac{x_{bo}}{F_{ao}} = \frac{-F_{ao}}{m\omega^2 F_{ao}} = -\frac{1}{m\omega^2}$$

Substituting the last two expressions into Equation 35,

$$\frac{x_{bo}}{x_{ao}} = \frac{M_{D,ba}}{M_{D,aa}} = -\frac{m\omega^2(k + j\omega c)}{m\omega^2(m\omega^2 - k - j\omega c)}$$

$$= -\frac{k + j\omega c}{m\omega^2 - k - j\omega c}$$

This solution contains imaginary terms in both numerator and denominator. Multiplying numerator and denominator by $m\omega^2 - k + j\omega c$ would place the imaginary terms in the numerator only. If a vector diagram similar to Fig. 7 is drawn, the square root of the sum of the squares of the real and imaginary parts results in the expected expression,

$$\frac{x_{bo}}{x_{ao}} = \left(\frac{k^2 + (c\omega)^2}{(c\omega)^2 + (k - m\omega^2)^2}\right)^{1/2}$$

The phase angle between x_{bo} and x_{ao} is

$$\tan^{-1} \frac{\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right] - \left(\frac{2c\omega}{c_c\omega_n}\right)^2}{\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right] + \left(\frac{2c\omega}{c_c\omega_n}\right)^2}$$

EXAMPLE 2: For the system depicted in Fig. 11*a*, a harmonic torque, 10 sin 1000*t*, is applied to the 1-in. diam steel shaft at point *E*, which is 8 in. from the fixed support. Assume that the system has no damping and that steady-state conditions have been attained. Find, by means of velocity-mobility and velocity-impedance methods: 1. Amplitude at point *E* on the shaft where the impressed torque is applied. 2. Amplitude of the disk.

Two springs must be considered in the analysis. One spring, k_1, is located between point *E* and the support, while the other spring, k_2, is between the disk and point *E*. Then, if $G = 12 \times 10^6$,

$$k_1 = \frac{G\pi d^4}{32L} = \frac{12 \times 10^6 \pi 1^4}{32 \times 8} = 147{,}500 \text{ in.-lb per rad}$$

$$k_2 = \frac{12 \times 10^6 \pi 1^4}{32 \times 24} = 49{,}200 \text{ in.-lb per rad}$$

First step is to draw the schematic diagram, Fig. 11*b*. Some of the applied torque is transmitted through spring k_1 directly to ground, and the remainder passes through spring k_2 to accelerate the disk. Thus, the system contains two branches that act in parallel. Action between spring k_2 and the disk is in series since the same force, or torque, acts on each component while there is relative motion between point *E* and the disk. Points of specific interest in Fig. 11*b* are *a*, *b*, and *E*.

Velocity mobilities of the components are:

$$M_{Vs1} = \frac{j\omega}{k_1} = \frac{1000\,j}{147{,}500} = 0.0068\,j \text{ rad}^2 \text{ per in.-lb-sec}$$

$$M_{Vs2} = \frac{j\omega}{k_2} = \frac{1000\,j}{49{,}200} = 0.0203\,j \text{ rad}^2 \text{ per in.-lb-sec}$$

$$M_{Vm} = -\frac{j}{m\omega} = -\frac{j}{0.5 \times 1000}$$

$$= -0.0020\,j \text{ rad}^2 \text{ per in.-lb-sec}$$

Velocity mobility at point *b*, using Equation 18,[1] is:

$$M_{V,b} = M_{Vs2} + M_{Vm} = 0.0203\,j - 0.0020\,j = 0.0183\,j$$

while at point *a*, $M_{V,a} = 0.0068j$. Corresponding impedances for points *a* and *b* are:

$$Z_{V,a} = -147\,j$$

$$Z_{V,b} = -54.6\,j$$

Because the two branches act in parallel, Equation 21[1] applies, and combined impedance at point *E* is:

$$Z_{V,E} = Z_{V,a} + Z_{V,b} = -147\,j - 54.6\,j$$

$$= -201.6\,j = T_E/\dot{\theta}_E$$

Introducing the applied torque, $T_E = 10$ in.-lb, into this expression,

$$\dot{\theta}_E = \frac{10}{-201.6\,j} = 0.0497\,j \text{ rad per sec}$$

Dividing this velocity by the value of $j\omega$, or $1000j$, gives a displacement amplitude of 0.0000497 rad, or 0.00284 deg.

Transfer mobilities and impedances must be used to obtain response of the disk. The portion of input torque acting in the disk branch is in the ratio of the impedances, or $T_b = (Z_{V,b}/Z_{V,E})T_E$. Angular velocity of the disk is: $\dot{\theta}_m = M_{Vm}F_b$. Then, transfer mobility, or velocity of the disk resulting from the excitation at *E*, is

$$M_{Vm,E} = \frac{\dot{\theta}_m}{T_E} = \frac{M_{Vm}T_b}{T_E} = \frac{M_{Vm}Z_{V,b}T_E}{Z_{V,E}T_E} = \frac{M_{Vm}Z_{V,b}}{Z_{V,E}}$$

Substituting the numerical values found previously into this expression gives

$$M_{Vm,E} = \frac{-0.0020\,j(-54.6\,j)}{-201.6\,j} = -0.00054\,j = \frac{\dot{\theta}_m}{T_E}$$

The negative sign indicates that angular velocity is out of phase with the impressed torque. Dividing this maximum angular velocity by $j\omega$, or $1000j$, and converting the answer to degrees gives a disk response displacement amplitude of -0.000308 deg.

Next article in this series will show how the three methods of analysis are used to find response of a lumped system with two degrees of freedom.

REFERENCES

This article is the second in a series by Austin H. Church on simplified vibration analysis. The previous article and issue of MACHINE DESIGN in which it appeared are:

1. "Mobility and Impedance Concepts" .....February 18, 1960

Other references in this article are:

2. R. E. D. Bishop—"The Analysis and Synthesis of Vibrating Systems," *Journal of the Royal Aero. Soc.* (British), October, 1954, pp. 703-719.
3. C. R. Freberg and E. N. Kemler—*Elements of Mechanical Vibration*, John Wiley & Sons Inc., New York, 1949, Ch. 9.
4. H. M. Hansen and P. F. Chenea—*Mechanics of Vibration*, John Wiley & Sons Inc., New York, 1952, Ch. 6.
5. R. Plunkett—"Semi-Graphical Method for Plotting Vibration Response Curves," *Proc. of the 2nd U. S. National Congress of Applied Mechanics*, ASME, June, 1954, pp. 121-126.
6. R. Plunkett—"Measurement of Mobility," *Journal of Applied Mechanics*, September, 1954, pp. 250-256.

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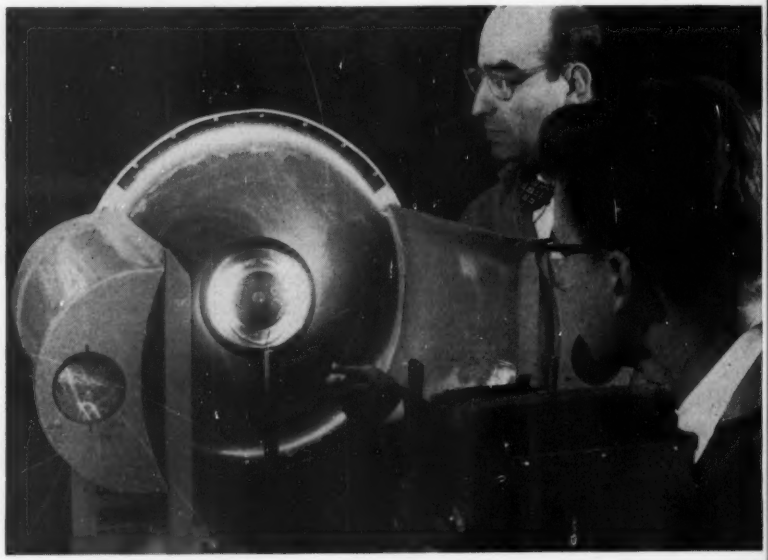

Fig. 1—Flow pattern of a model impeller. Sparks form visible streamlines.

Air, Sparks, and Lampblack used for

Visualizing Gas Flow

INDUSTRIES which deal in fluid flow find a growing need to design flow passages more critically. Pumps, rockets, ships, and even hydrogen-cooled generators are demanding more refined evaluation of their flow patterns. The two methods presented here give the designer a rapid, easy-to-see picture of the flow pattern in gases. These methods form a complement to those used in liquid flows, of injecting a dye into the stream to see the pattern.

The method shown in Fig. 1 and 2 consists of introducing glowing particles from a special sparkler into the air stream and photographing their paths. Fig. 1 is a spark display of the flow pattern of an impeller and the passages of a model turbogenerator, designed to be cooled ultimately with hydrogen. Fig. 2 is a wind-tunnel system constructed both to test sparklers and various passage sections.

Successful sparklers must be specially made to insure proper particle size, mass, and burning life. Ordinary "Fourth of July" sparklers proved unsatisfactory. Correct photographic technique is also important.

The method shown in Fig. 3 yields a graphic picture of the velocity profile across a test section of the tunnel. The profile is obtained by inserting an oil-impregnated screen at the desired section. Lampblack is then introduced into the suction end of the blower. The lampblack particles blown downstream are deposited on the screen. Particles which do not adhere to the screen are blown out the exhaust of the system. The screen is then removed from the tunnel, and light reflected from different areas of the screen is then measured by a photometer. The voltages indicated by the meter can be interpreted as relative velocities. Care must be taken in the analysis of the profile obtained to allow for excessive "blow through," negative velocities, and similar problems.

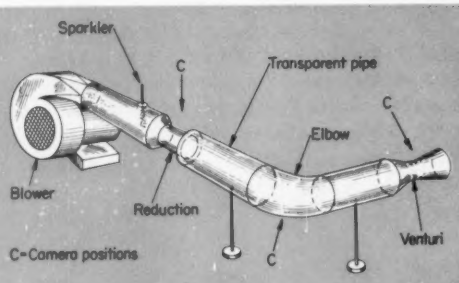

Fig. 2—Setup for photographing sparks moving through typical flow sections.

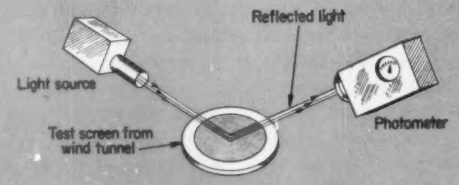

Fig. 3—Velocity measure from lampblack density.

Plastics for Extrusions

- **Properties**
- **Service characteristics**
- **Application comparisons**
- **Extrudability**

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NUMBER of plastics available for extrusion seems to grow exponentially. The rapid progress of research in recent years has made available a wide range of completely new polymers, copolymers, alloys, and simple mixtures of various basic raw materials. Although it is almost impossible to give a complete list of plastics suitable for extrusion, the properties of some of the more popular ones are summarized in Table I.

The material plays a strong role in the extrudability of a particular shape. For example, high-impact styrene is easiest to extrude. The cellulosics, such as cellulose acetate butyrate and ethyl cellulose, are next in line, with acrylic approximately similar in extrudability. The most difficult material is nylon.

Where very intricate cross sections are required, a shape could perhaps be extruded in rigid vinyl, but not in linear polyethylene. Close tolerances might be held if the shape were specified in butyrate, but double the tolerances would be necessary for a similar polyethylene extrusion.

A relatively simple shape can turn into a very intricate one because of material. Nylon was re-

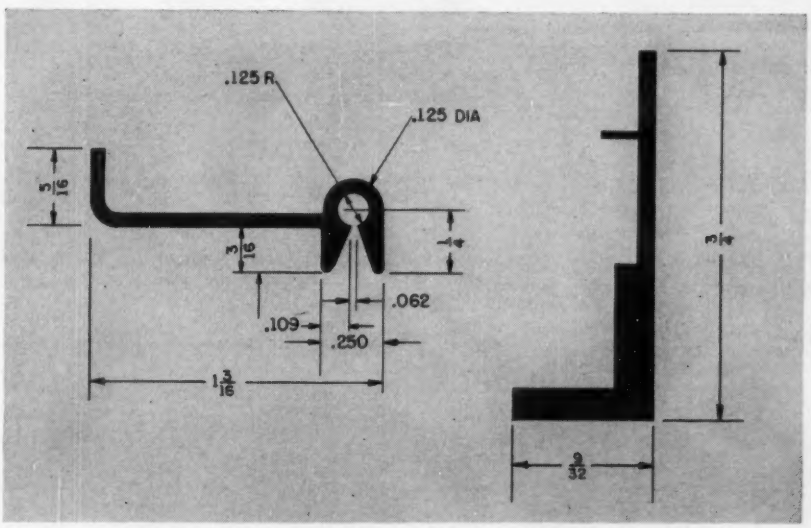


Fig. 1—Shapes which are difficult to extrude in nylon, but easier to extrude in a plastic such as rigid PVC.

Table 1—Guide to

1—Cellulose Acetate

Least expensive of the cellulose ester plastics. Well suited for applications which do not require extreme resistance to long exposure to water or outdoor sunlight. Formulations range from rigid to highly flexible, in any color, transparent, translucent, or opaque. Have very low odor and taste levels. Thin sections possible. Resists oils, gasolines, greases, and most cleaning fluids which do not contain aromatic or chlorinated hydrocarbons. Easily cleaned with soap and water.

2—Cellulose Acetate Butyrate

Chemically related to cellulose acetate and similar to it except harder, tougher, and more resistant to heat. In special weather-resistant formulations, can stand 5 years or more of continuous exposure. Available in a full range of colors and flows.

3—Cellulose Propionate

Newest of the cellulose ester plastics. Chemically related to cellulose acetate and even more closely to cellulose acetate butyrate. High hardness with very good toughness. Like other cellulosics, available in a full color range, but flows are normally restricted to the harder degrees. Odorless. Weather resistance slightly less than butyrate.

4—Ethyl Cellulose

Toughest and lightest of the cellulosics. Rigid with considerable springiness; chip-proof; weather resistant. Retains stability at low temperatures and high humidity. Slightly duller finish than other cellulosics. Special formulations can be compounded.

5—Polyethylene

Flexible, tasteless, odorless, nontoxic, inert, and has no known solvent at room temperatures. Remarkable electrical properties over wide frequency and temperature range. Very light and almost zero moisture absorption. Special formulation (Aeroflex P), developed to resist stress cracking due to alcohols, solvents, detergents, and chemical atmospheres, is especially useful for tubing applications.

6—Linear Polyethylene

High-density type—stiffer, harder, more heat re-

Properties	1 Cellulose Acetate	2 Cellulose Acetate Butyrate	3 Cellulose Propionate	4 Ethyl Cellulose	5 Polyethylene	6 Linear Polyethylene
Specific Gravity	1.32	1.19	1.20	1.10	0.92	0.95
Tensile Strength at 77 F (psi)	6100	4400	4500	5000	1300	>3450
Izod Impact Strength at 77 F (ft-lb/in. of notch)	1.20	2.80	9.50	3.00	No Break	2.75
Rockwell Hardness at 77 F	R 100	R 90	R 67	M 17	45†	66†
Heat-Distortion Point at 66 psi (F)	189	180	167	158	107	155
Volume Resistivity (ohm-cm)	10^{11}	10^{11}	$>10^{12}$	10^{13}	$>10^{15}$	10^{15}
Dielectric Strength (v/mil)	360	380	375	400	460	450
Water Absorption, 24 hr immersion (per cent)	3.00	1.60	1.90	1.20	0.01	0.03
Flammability (in./min)	0.90	1.15	<1.50	1.00	1.10	0.95
Effect of Acids	——Slightly affected by weak. Decomposed by strong.——				——None——	
Effect of Alkalis	——Slightly affected by weak.—— Decomposed by strong.			Weak: None. Strong: Slight	——None——	
Effect of Organic Solvents	Soluble in ketones and esters. Softened or slightly soluble in alcohol. Little affected by hydrocarbons.			Widely soluble.	None under 122 F.	None under 122 F except trichlorethylene.
Clarity	——Transparent to opaque.——			——	Translucent to opaque.——	

Properties are for: 1. Tenite I, 007EH. 2. Tenite II, 265MH. 3. Tenite P 307E. 4. Ethocel R3. 5. Aeroflex. 6. Super Aeroflex. 7. Profax 6511E. 8. Styron 666. 9. Bakelite TGD-6000. 10. Tyril. 11. Cycolac L. 12. Lucite HM129. 13. Zerlon 150. 14. Zytel 42. 15. Lexan. 16. Delrin 150 series. 17. Geon 8750.
*At 73 F. †Shore Durometer. §At 264 psi.

Extrudable Plastics

sistant than regular polyethylene. Excellent low-temperature toughness. Greater tensile strength permits design of thinner cross sections.

7—Polypropylene

Combines chemical inertness typical of polyethylene with hardness, strength, and stiffness characteristics of cellulosics. Lightest of all plastics (it floats). Resists distortion at temperatures to 300 F. Broad range of colors, with attractive, lustrous finish. Highly chemical resistant. Probably most economical, rigid material with widest range of desirable properties, available.

8—Polystyrene

Low cost, crystal clear, practically no cold flow, low specific gravity, extremely low water absorption. Electrical properties comparable to polyethylene. Thin sections should be avoided since material is rigid but brittle. Impact, heat and light-resistant grades available.

9—High-Impact Polystyrene

Chemical and electrical properties similar to styrene but 3 to 5 times the impact strength and 10 times the elongation. Next to general-purpose and medium-impact styrene, the most economical material for rigid extrusions. Opaque, semiglossy color only.

10—Styrene-Acrylonitrile Copolymer

Similar to styrene but less subject to crazing. Resistant to gasoline and kerosine. High critical elongation, good heat resistance, moderate toughness. All colors and clear.

11—Acrylonitrile-Butadiene-Styrene (ABS)

Best known for good balance of critical properties—excellent impact strength even at low temperatures, chemical resistance and full color range with good surface finish. Excellent electrical properties. Extrusions are easily formed and fabricated.

12—Acrylic Resins

Noted for beauty, clarity, and shatter resistance. One-third as heavy as optical glass but compar-

7	8	9	10	11	12	13	14
Polypropylene	Polystyrene	High-Impact Polystyrene	Styrene-Acrylonitrile Copolymer	Acrylo-nitrile-Butadiene-Styrene	Acrylic Resin	Styrene Methyl Methacrylate	Nylon
0.90	1.06	1.04	1.08	1.02	1.18	1.14	1.14
5000	6500	3200	10,500	5100*	9000	9000	11,900*
1.00	0.45	1.10	0.40	6.20*	0.50	0.40	1.30*
R 95	M 73	L 78	M 80	R 86	M 98	M 78	R 118
221	175§	175§	180§	208	179§	205§	360
3×10^{15}	10^{17}	$>10^{14}$	$>10^{16}$	$>3.9 \times 10^{16}$	$>10^{15}$	$>10^{16}$	4.5×10^{13}
500	600	500	550	360	400	500	385
0.03	0.04	0.10	0.28	0.27	0.40	0.20	1.50
0.70	1.00	0.89	0.60	3.47	1.50	1.70	Self-extinguishing
None. Slow attack by strong oxidizing.	——Attacked by strong oxidizing.——			Attacked by highly concentrated oxidizing.	Attacked by strong oxidizing.	——Attacked by strong.——	
——None——					Practically none.	Practically none.	Weak: none.
None below 150 F.	Dissolves in chlorinated and aromatic hydrocarbons.			Attacked by high KB aromatic hydrocarbons.	Dissolves in esters and aromatic hydrocarbons.	Dissolves in chlorinated and aromatic hydrocarbons.	Resists common solvents.
Translucent to opaque.	Transparent—89% light transmission.	——Translucent to opaque.——		Opaque.	Transparent—98% light transmission.	Luminous transmittance.	Translucent to opaque.

Table 1 (Continued)

able in light transmission. Extremely high resistance to weather, heat, and scratches. Greater rigidity than cellulosics. All transparent, translucent, opaque, and pearlescent colors. A modified acrylic has excellent impact resistance, smooth finish, and can be punched or stapled. Available in color and milky white, it is excellent for clip-type extrusions.

13—Styrene-Methyl Methacrylate

Copolymer with excellent clarity, weatherability, processability, and toughness. Good strength, heat resistance, and light stability. Properties and economy lie in between acrylics and styrene. Light transmission of greater than 91 per cent places material in the range of optical glass.

14—Nylon

Tough, lightweight, low coefficient of friction, very high tensile strength. Serviceable at temperatures as low as −70 F, form-stable to 400 F. Fairly high water absorption increases impact strength. Extrudable in small-diameter rods, tubes, and shapes.

15—Polycarbonate

Semiflexible. Suitable for food applications and steam sterilization. Outstanding combination of impact strength, heat resistance, dimensional stability, electrical properties, creep resistance, and high and low-temperature strength. Molded parts are transparent, self-extinguishing, and nontoxic.

16—Acetal Resin

Tough, rigid, with low-friction properties approaching fluorocarbons. Useful continuous service temperature range, −40 to +185 F; short time to 300 F. Low moisture absorption assures good dimensional stability. Best resistance to solvents, oils, gasolines, and hydraulic fluids. Not recommended for strong acids or alkalis.

17—Rigid Polyvinyl Chloride (Rigid PVC)

Combines toughness and structural strength with chemical inertness, good outdoor aging characteristics, excellent electrical properties, and abrasion resistance. Hard, tough, lightweight, and nonflammable. Supplied in high-impact and normal-impact compounds, the latter suitable for outdoor use. Suitable for intricate extrusions.

Properties	15 Polycarbonate	16 Acetal	17 Rigid Polyvinyl Chloride
Specific Gravity	1.20	1.43	1.38
Tensile Strength at 77 F (psi)	8500	10,000*	7000
Izod Impact Strength at 77 F (ft-lb/in. of notch)	14	1.40*	0.81
Rockwell Hardness at 77 F	R 118	R 120	80†
Heat-Distortion Point at 66 psi (F)	288	338	160§
Volume Resistivity (ohm-cm)	2.1×10^{13}	6×10^{14}	10^{12}
Dielectric Strength (v/mil)	400	500	1413
Water Absorption, 24 hr immersion (per cent)	0.35*	0.12	0.06
Flammability (in./min)	Self-extinguishing.	1.10	Self-extinguishing.
Effect of Acids	Slightly affected by concentrated.	Attacked by strong. Resistant to some weak.	Not affected by most.
Effect of Alkalis	Attacked by strong.	Attacked by strong. Resistant to some weak.	Not affected by most.
Effect of Organic Solvents	Soluble in chlorinated hydrocarbons.	Practically none.	Not recommended for most organic solvents.
Clarity	Transparent.	——Translucent to opaque.——	

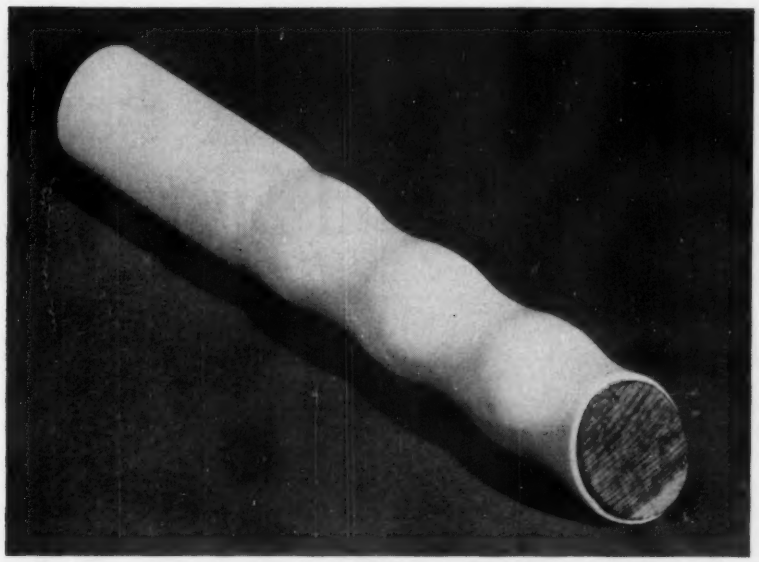


Fig. 2—Plastic extrusion shrunk over a wooden core by special processing techniques.

quired for the parts in both Fig. 1 and 2. Nylon is difficult to extrude in irregular shapes such as these. While other plastics soften gradually and can be extruded in a semiliquid consistency, nylon will not extrude unless it is brought to a temperature at which it immediately becomes quite liquid. In nylon it is best to avoid massive sections, and adjacent sections with sharply differing wall thickness. If the shapes in Fig. 1 were specified in a rigid polyvinyl chloride, for example, they would not be hard to extrude.

Probably the two most popular materials specified for rigid-profile extrusions other than tubes are cellulose acetate butyrate and high-impact polystyrene. The former is a glossy-finish material and the latter, satin-finish.

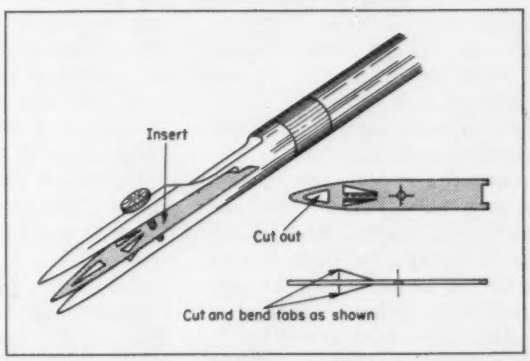
Of the materials listed, the only one considered flexible—approximately the flexibility of leather—is polyethylene. For rubber-like flexibility, the plasticized vinyls (not described in detail here) can be specified and compounded to almost any hardness required.

With flexible or semiflexible materials, extrusion tolerances should be looser than those normally specified for rigid plastic, and most certainly less demanding than for metal extrusions. It is meaningless to specify a ± 0.005 in. tolerance, for example, on a $\frac{1}{2}$ in. thin-walled polyethylene channel opening. This dimension could not be measured accurately since polyethylene is flexible. In most cases, such flexible extruded parts are inserted in, or attached to, other rigid components. The plastic extrusion will conform to the contour and tolerances of the mating part without difficulty.

Special formulations are entirely possible. For example, a shrink-fitting thermoplastic has been developed. The material, based on cellulose acetate, is supplied in finished extruded forms, ready for assembly. Whenever the material is to be activated, it is immersed in an inexpensive solvent for 15 minutes (no damage is caused even if left in the solution for an hour) and applied over the metal, wood, or other material which it is designed to cover, Fig. 2. Shrinking takes place as it dries. The assembly can be handled within 20 to 30 minutes, and the plastic part will be completely dry after 24 hr.

Tips and Techniques

Preventing Ink Spreading



Wide lines can be drawn without ink spreading by an insert which fits the conventional pen. The insert can be made of 0.005 in. thick sheet steel or 0.010 in. acetate.—Chas. H. Sekera, *Westinghouse Research Lab., Pittsburgh, Pa.*

Transient Loads in Fluid Systems

H. A. WEIGAND
Ingersoll Rand Co.
Chicago, Ill.

LEE B. EDDY
Universal Oil Products Co.
Des Plaines, Ill.

ACCURATE analyses of electrical motor and system behavior during various types of transient conditions, makes it necessary to establish moment of inertia WK^2 and speed-torque characteristics of the driven machine. In general terms, this paper presents typical WK^2 values and speed-torque characteristics of centrifugal pumps and compressors. The values presented occur during normal starting periods and immediately following momentary voltage failures to the driving motors.

Liquid System Characteristics: To establish the torque requirement of a pump at any particular instant, it is necessary to know the differential pressure across the pump as a function of liquid flow through the pump. Three types of differential pressures are: Static head, friction head, and velocity head. An actual liquid system usually involves a combination of all three types.

Since pressure loss due to velocity is usually small compared to friction loss, this paper combines friction and velocity head into one characteristic, friction head, which varies as the square of flow. Specific systems are identified by the percentage of static head compared to the total differential pressure.

Frequently, the flow in a liquid system fed by a centrifugal pump is controlled by a valve or other restriction. A system has different over-all characteristics for each position of the restriction.

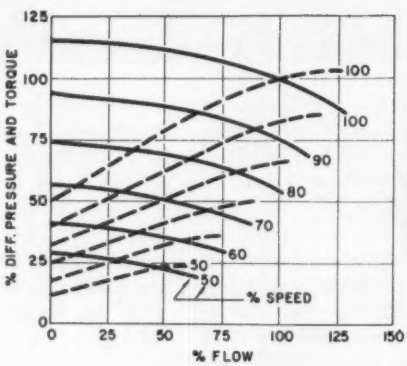


Fig. 1—Pressure and torque characteristics of a radial-flow pump operating at different speeds. Solid lines are differential pressure. Dashed lines are torque.

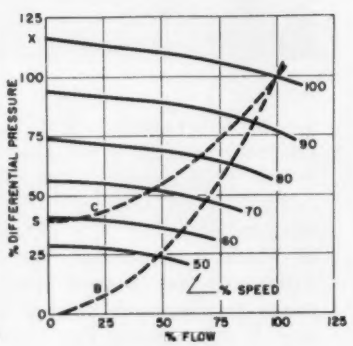


Fig. 2—Radial-flow pump and system characteristics. Solid lines are pump differential pressure. Line B is system pressure at zero static head. Line C is system pressure at 40 per cent head.

Pump Characteristics: In general, the inertia values of a motor driver is several times as great as the pump to which it is connected, and exact pump values can be obtained from the manufacturer. For any individual pump, the manufacturer can also supply characteristic curves of differential pressure (or head) and brake horsepower as a function of flow at given design speeds. Torque is directly proportional to horsepower and inversely proportional to speed. Typical torque and differential pressure characteristics, as a function of flow, are illustrated in Fig. 1.

Pump and System Characteristics: To determine torque under any given set of conditions, the liquid system characteristic curve is plotted on the same co-ordinates as the variable-speed pump pressure-flow curves, Fig. 2. Then, for any particular speed, the corresponding flow is determined from the intersection of the appropriate system and pump curves. Torque corresponding to known flow at one particular speed is determined from the torque-flow curve at that speed (dashed lines), Fig. 1. By plotting a series of these torque values at several different speeds, a pump speed-torque curve is derived, Fig. 3.

For the "no-flow" condition and for flow with zero per cent static head, pump torque is directly proportional to the square of speed as shown by lines A and B, Fig. 3. Where static head is greater than zero, the curve changes slope (line C) at the speed where flow begins. The pump has a check valve to prevent reverse flow.

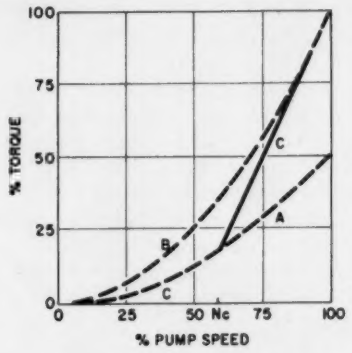


Fig. 3—Speed-torque characteristics for a radial-flow pump. Line A is no-flow condition. Line B is flow with zero static head. Line C is flow with 40 per cent static head.

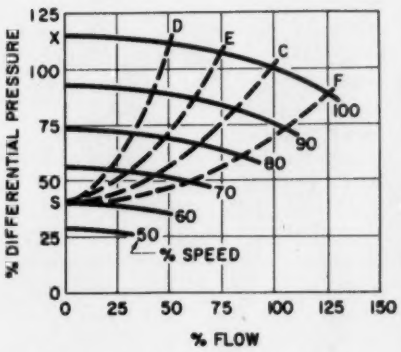


Fig. 4—Combined pressure-flow characteristics for a radial-flow pump and variable-liquid system with 40 per cent static head. Lines D, E, C, and F represent 50, 75, 100, and 125 per cent flow, respectively.

The per unit speed where flow begins, N_c, is equal to $(s/x)^{½}$, where s = per cent static head of the system and x = per cent of pump differential-pressure at zero flow and 100 per cent speed. See points s and x in Fig. 2. In certain applications, a control valve or other variable restriction in the fluid system will change position at the same time pump speed is changing. Different positions of a variable restriction produce a family of system-characteristic curves, (dashed lines), Fig. 4.

Pump Torque During Transient Conditions: Calculation of speed-torque characteristics of pumps during momentary power failures may require plotting the system and pump curves. For example, assume a radial-flow pump and a system having characteristics like Fig. 1 and 4. Under normal conditions, the system operates at 75 per cent flow. When electric power fails, the control valve opens completely in a known length of time and changes the system to 125 per cent flow. When the motor is re-energized, the pump speed-torque characteristics for 125 per cent flow will keep the control valve fully open until the machine has returned to 100 per cent speed.

Gas System Characteristics: Two types of gas systems are common: Simple compression and circulating. In a simple compression system, suction and discharge pressures remain nearly constant for various flow rates. In a circulating system, suction pressure usually remains constant but differential pressure varies approximately as the square of flow under normal operation. During transient conditions, the discharge pressure in a gas system will not change as rapidly as will pressure in a liquid system because the rate of change is a function of the system volume and the means by which system pressure is maintained. In this paper, gas systems are described only as to whether the compressor discharge pressure changes slowly or rapidly during transient conditions.

Compressor Steady-State Characteristics: Typical inertia values for centrifugal compressors are shown in Fig. 5. Effective inertia of a compressor with reference to a motor shaft is determined by multiplying the compressor inertia by the square of the ratio of compressor speed to motor speed. To obtain total load, the inertia of the gear unit and couplings (referred to the motor shaft) must be added.

Typical pressure-flow and torque-flow performance curves for a centrifugal compressor with fixed suction conditions are shown in Fig. 6. Characteristics are discontinued below 50 per cent flow because unstable or surging operation occurs

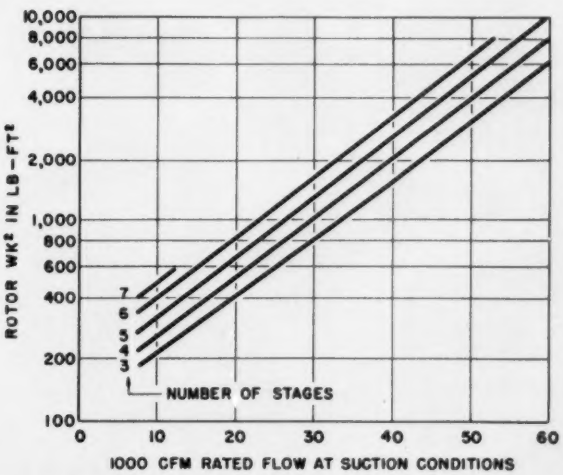


Fig. 5—Typical WK^2 values for centrifugal compressors.

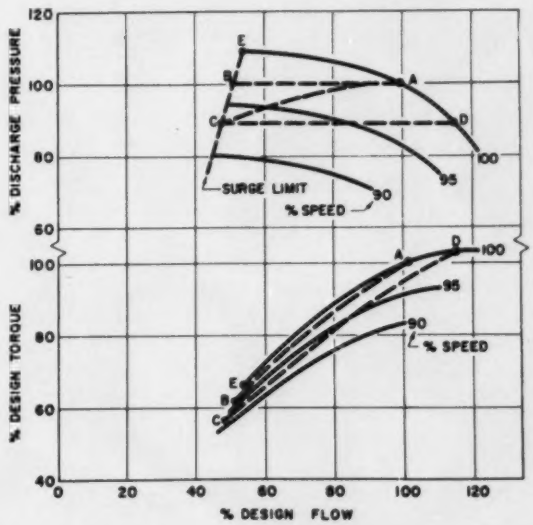


Fig. 6—Unthrottled compressor characteristics at various speeds.

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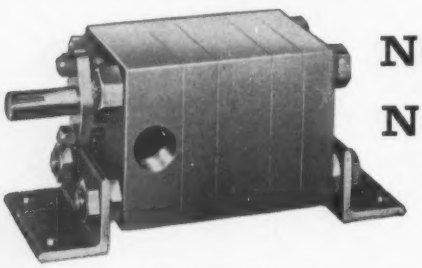

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in this range. With suction throttling, the operating range can be extended.

Discharge pressure developed by a compressor at constant flow and constant speed depends on the gas at suction conditions. Therefore, in analyzing transient compressor behavior, performance curves for that particular gas, and a set of conditions which impose the greatest anticipated load on the driver must be used.

Characteristics During Transient Conditions: Starting of a centrifugal compressor seldom presents a torque problem. At full speed, torque can usually be kept to less than 25 per cent of full-load value. At lower speeds torque is roughly proportional to speed.

In Fig. 6, assume that the unit is operating at its rating, point A, when the voltage fails to the motor driver. If the pressure remains relatively constant during the decelerating period, the compressor operation follows the path AB. Soon after passing the surge limit B, the compressor is not able to develop enough discharge pressure to force gas into the system. The discharge check valve closes and causes the compressor to operate at a no-flow condition. Hence, torque at the surge line is assumed identical to that at no-flow. Furthermore, it is assumed that no-flow torque varies as the square of the speed. Full-speed torque is point E. Upon voltage failure the speed drops quickly from operating point A to no-flow point B, and then to complete rest.

When the motor is re-energized the compressor speed-torque curve during the accelerating period is similar to that described for the decelerating period, if discharge pressure has not changed. The curve will differ, however, if a substantial decrease in discharge pressure takes place during the momentary voltage failure.

Effects of Suction Throttling: In many constant-speed compressor applications, the flow is controlled by means of a damper, valve, or set of guide vanes located on the suction side of the compressor. The effect of such a variable restriction is the lowering of gas pressure at the com-

pressor intake which, in turn, reduces the weight flow of gas and the discharge pressure.

AIEE Paper No. 60-16 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 8 pp.

electrical

Standard Definitions For Mechanical Rectifiers

Mechanical Rectifier Subcommittee of the AIEE Industrial Power Rectifier Committee

Definitions which apply particularly to the type of mechanical rectifier with groups of contacts sequentially driven by a synchronous motor. The magnetic rectifier, in which contacts are individually operated by electromagnets without intermediate mechanical linkages, is not specifically covered. However, many of the terms are applicable to both types.

Categories of definitions include: Equipment, parts and auxiliaries, circuits, functional terms, rating, characteristics, and operating faults. Symbols for the excitation circuits and properties of mechanical rectifiers are omitted.

AIEE Paper No. 60-35 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 17 pp.

Bibliography of Relay Literature 1957-1958

Subcommittee on Bibliography of Relay Literature of the AIEE Relays Committee

A total of 159 listings of papers in 13 sections including: Apparatus protection, general and miscellaneous relaying, methods and calculations, and electronic relays.

AIEE Paper No. 60-26 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 14 pp.

lubrication

Oxidation of Lubricating Oils At High Temperatures

Albert L. Williams and Edward A. Oberright, Research and Development Laboratory, Socony Mobil Oil Co.

Liquid-phase oxidation of lubricating oils at high temperatures under

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highly oxidative conditions. The oxidation rate is dependent upon oil temperature. For rapid oxidations (above 100 ml of oxygen consumed per 5 min), temperature control is the most important variable. Slow oxidations (below 10 ml per 5 min) are influenced by small errors inherent in the operation of the test unit and may differ by as much as 100 per cent. However, all oils that have an oxidation rate of 10 ml or less per 5 min are classified as very stable.

ASME Paper No. 59-LUB-8 presented at the ASME-ASLE Lubrication Conference, New York, October, 1959, 8 pp.

mechanical

Vibratory vs. Rotating-Wheel Gyroscopic Rate Indicators

G. C. Newton Jr.
Massachusetts Institute of Technology

Alternatives to the rotating-wheel gyroscope in the form of devices which are based on the principle of vibratory rather than rotary motion of mass elements. The tuning fork is typical. Three quantities are considered in making the comparison: 1. Sensitivity, in terms of output signal per unit angular rate. 2. Thermal fluctuations (or noise) which are inherent in the measuring technique. 3. Ratio of thermal fluctuations to sensitivity. The last two quantities express the ultimate performance limitations which are inherent in these instruments.

If it should prove to be possible to overcome the cross-coupling problems encountered in the vibratory instrument, its performance may be improved to the point where thermal noise becomes a practical consideration.

AIEE Paper No. 60-62 presented at the AIEE Winter General Meeting, New York, January-February, 1960, 18 pp.

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ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

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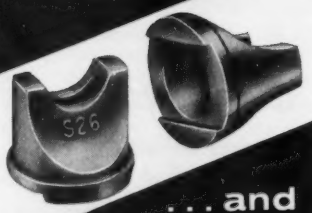

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Industrial Plastics

Properties, applications, and availabilities of Polypenco nylon, Teflon, Fluorosint TFE base resin, and other new industrial plastics are outlined in illustrated booklet BR-O. Similar coverage is alloted to Nylaflow nylon tubing and Nylaflow braided hose. Also included are data on Nylasint sintered parts and Nylatron molding powders, as well as engineering information on finishes for Whirlclad coating system. 16 pages. Polymer Corp., 2120 Fairmont Ave., Reading, Pa.

Circle 601 on Page 19

Hose Fittings and Hose

Reusable hose fittings, assemblies, adaptors, and single and double wire-braid hose are designed for high, medium, and low pressures in universal industrial applications. They are pictured and detailed with specification tables in Catalog H10-59. Eight sections cover various types. Diagrammed assembly instructions are included. 8 pages. Lenz Co., 3301 Klepinger Rd., Dayton 1, Ohio.

Circle 602 on Page 19

X-Y Recorder

Bulletin 794-1 gives complete data on large-scale (24 x 36-in.) x-y recorder offering direct differential transformer or ac transducer input. New circuit extends triple advantages of precision accuracy, large-scale readout, and direct ac input. Vacuum hold-down, changeable multicolor traces, and precision attenuators are standard features. 2 pages. Houston Instrument Corp., P. O. Box 22234, Houston 27, Tex.

Circle 603 on Page 19

Subminiature Valves

Trim Line air control valves are 1 in. thick by 1½ in. wide, and are available in six valve actions. Details of valve actions are shown in cutaway views. Bulletin 592 includes illustrations of the six actions plus dimensional drawings, complete description and specifications, and JIC diagrams. 12 pages. Hunt Valve Co., Salem, Ohio.

Circle 604 on Page 19

Vibrating Feeders

Motorized Counterweight vibrating feeders in more than 60 sizes are illustrated and described in Book 2869. Both single and twin-motor types in either floor-mounted or cable-suspended models are shown. Selection and application information is given on feeders in all size ranges. Bulletin provides illustrations of many possible applications. 12 pages. Link-Belt Co., Dept. PR., Prudential Plaza, Chicago 1, Ill.

Circle 605 on Page 19

Electrical Resins

More than 20 flexible, semiflexible, rigid, and special resins, with examples of their applications, are described in comprehensive Catalog 1292.5. Covering the entire line of commercially available Scotchcast electrical resins, it tells how to select the best resin system for a job and how to store and prepare resins. It also explains handling, application and curing techniques, discusses molds and mold releases, and suggests methods of component design and preparation. 28 pages. Minnesota Mining & Mfg. Co., Dept. WO-10, 900 Bush Ave., St. Paul 6, Minn.

Circle 606 on Page 19

Toggle-Switch Assemblies

High-performance toggle switches and toggle-switch assemblies for use in airborne, mobile, marine, electronic, and commercial applications are described in Catalog 73d. It includes military versions, pull-to-unlock, hermetically sealed, electrical-memory, rocker-actuated, and miniaturized designs. Detailed descriptions, photographs, diagrams, dimensional drawings, and specification tables are included. 32 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.

Circle 607 on Page 19

Diesel Engine

Four-cycle, six-cylinder diesel engine, UDT-817, is available in turbocharged or naturally aspirated models. Catalog CR-607-I provides specifications on the two models and lists various applications. 16 pages. International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill.

Circle 608 on Page 19

Multichannel Plotters

Complete line of multichannel plotters is described in Bulletin PG-100. Specifications, application data, and operation information are given for each of seven different models. 8 pages. Gilmore Industries Inc., 13015 Woodland Ave., Cleveland 20, Ohio.

Circle 609 on Page 19

Laminated Plastics

Two copper-clad, flame-retardant laminated plastics, Fireban 321-R and Fireban 321-E, offer excellent electrical and punching characteristics, and base stock has high insulation resistance and surface resistivity. Described in Technical Data Bulletin 3.1.25.1, materials meet tentative UL requirements for flame retardance. Properties listed include bond strength, dissipation factor, insulation resistance, surface resistivity, and heat resistance. 2 pages. Taylor Fibre Co., Norristown, Pa.

Circle 610 on Page 19

Mercury Thermostats

Bulletin 684 describes three standard mercury thermostat groups: Well-type for sensing case temperature, duct-type for gas of fluid-temperature sensing, and surface-type for area-contact temperature sensing. Line drawings are provided for each type. 18 pages. Vapor Heating Corp., Vap-Air Div., 6420 W. Howard St., Chicago 48, Ill.

Circle 611 on Page 19

Welding Fittings and Flanges

Technical Bulletin FDC-275 catalogs 36-in. nominal pipe sizes. Dimensional and physical data are given for various elbows, returns, tees, reducers, caps, and lap-joint stub ends. 4 pages. Babcock & Wilcox Co., Tubular Products Div., Welded Fittings Dept., Milwaukee 46, Wis.

Circle 612 on Page 19

Canned Pumps

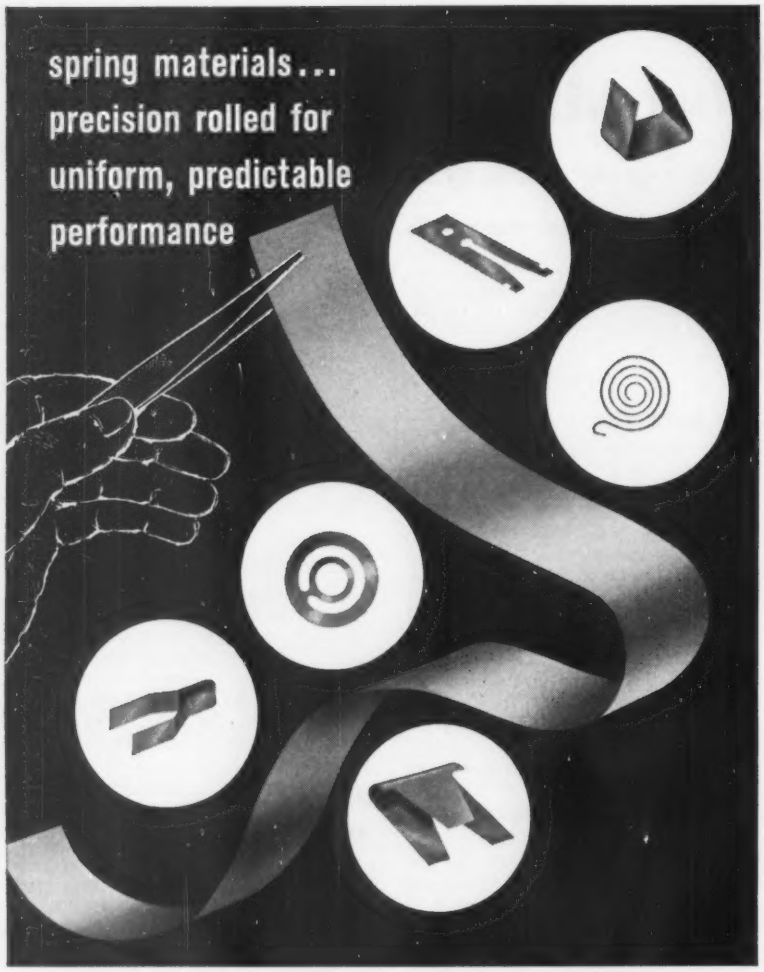
Series C sealless canned pumps provide leakproof pumping of corrosive, toxic, explosive, radioactive, and other problem fluids. Two-color Bulletin 1050-4 gives design features and model specifications. 8 pages. Fostoria Corp., Chempump Div., P. O. Box 35-27, Huntingdon Valley, Pa.

Circle 613 on Page 19

Switches and Terminals

Completely revised catalog contains comprehensive data on multicircuit push-button switches, multicircuit stack switches, range-heater, motor-reversing, toggle, and slide switches. Catalog gives details of handles, hardware, shaft styles, and terminals. It includes dimensional drawings, wiring diagrams, circuit sequences, and electrical ratings for each switch. Terminal section provides a tabulation of male and female quick-connect terminals, and includes a variety of adapters, connectors, terminal multipliers, and multicontact stationary terminals. 24 pages. Ark-Les Switch Corp., 51 Water St., Watertown 72, Mass.

Circle 614 on Page 19



Here—from Precision Metals Division of the Hamilton Watch Company—are important new spring materials. Now available in production quantities are flat wire and metal strip of Beryllium Copper, Elinvar, Havar, Stavar, Inconel Extra and Age-Hardening Stainless Steel.

The newly expanded and completely integrated Precision Metals Division is producing these spring materials with these unusual advantages:

thicknesses from .010" to .0001"
extremely close tolerances
dimensional uniformity

controlled metallurgical properties
excellent surface characteristics

In addition, Precision Metals Division will also furnish special alloys to your own specifications in the particular form you require. Write today for a copy of facilities booklet MD-3 or mail your prints for proposal.

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WATCH COMPANY / **Precision Metals Division**
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Representatives
COREY STEEL COMPANY • Chicago, Illinois
FAGERSTA STEELS PACIFIC, INC. • Los Angeles, California

Circle 479 on Page 19

HELPFUL LITERATURE

Eddy-Current Coupling Drives

The Kinatrol, an eddy-current coupling, packaged, adjustable-speed drive, available for 3 to 100 hp requirements, is described in Bulletin GEA-6885. Liberally illustrated, the bulletin covers principle of operation, construction features, dimensions, and ratings. 12 pages. General Electric Co., Schenectady 5, N. Y.

Circle 615 on Page 19

Digital Volt-Ohmmeter

Fully transistorized digital volt-ohmmeter has no stepping switches or relays. It is fast and has accuracy better than 0.1 per cent dc. Modular design is versatile, offers a variety of outputs. Unit, Model DV803, is described in fold-out card. 6 pages. Epsco Inc., 275 Massachusetts Ave., Cambridge, Mass.

Circle 616 on Page 19

Servo Motors

High-response dc servo motors in sizes from ¼ through 1 hp provide fast response in industrial applications requiring rapid starts, stops, and reversals. Bulletin C-2503 includes a list of features, dimensions, characteristics, and typical applications. 2 pages. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 617 on Page 19

Metalworking Processes

Titled "How Moving Metal Reduces Parts Cost," Bulletin 900-P5 describes stamping, upset forging, rotoforming, and other metalworking processes. Bulletin graphically illustrates with actual case histories how money is saved while maintaining quality and precision levels. Also included are examples of facilities available. Detailed information on hydraulic equipment and tunnel and shaft-support systems is also given. 24 pages. Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown 1, Ohio.

Circle 618 on Page 19

Fastener Selection

Seventeen case histories in fully illustrated Bulletin 353 describe assembly savings achieved in various industries through the use of Speed-Nut fasteners. More than 9000 variations of fasteners are available. 18 pages. Tinnerman Products Inc., P. O. Box 6688, Cleveland 1, Ohio.

Circle 619 on Page 19

Subminiature Connectors

Series SM connectors are made to military-approved specifications in a variety of contact sizes. Illustrated catalog gives specifications, outline dimensions, and general information. Aluminum hoods, protective shells, and patented polarizing screw-locks are also described. 12 pages. DeJur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 620 on Page 19

Breadboard Components

Pocket-sized Technical Booklet 4 on mechanical breadboard components such as gears, shafts, and couplings, provides numerous design hints and recommendations for instrument engineers and designers. Booklet tells how to assemble a model, using stock components, and includes a list of "do" and "don't" rules for mechanical assembly. List of components available is furnished. 24 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 621 on Page 19

Insulated Thermocouples

Catalog 300 on mineral-insulated thermocouples gives five simple ordering steps which provide prompt delivery of over 24,000 assembly combinations from stock of all components. Steps in manufacturing and testing thermocouples are illustrated. Catalog also includes complete line of hot junctions, terminations, and mounting methods. 18 pages. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

Circle 622 on Page 19

Proximity Limit Switch

Gemco limit switch has excellent sensitivity, and is for temperatures from −50 to +250 F. Two-page bulletin shows various applications, gives characteristics and application data. General Equipment & Mfg. Co., 116 S. Campbell St., Louisville 6, Ky.

Circle 623 on Page 19

Explosionproof Housings

Design information, as well as detailed drawings, photographs, and dimension charts for cast-aluminum housings for explosionproof and weatherproof applications are provided in Bulletin 160. Also covered are special housings and fittings, and a section is devoted to dust-tight units with glass windows for instruments and meters. 16 pages. Adalet Mfg. Co., 14300 Lorain Ave., Cleveland 11, Ohio.

Circle 624 on Page 19

Stainless-Steel Tubing

Basic technical information on stainless tubing is provided in Catalog 10. Data included are size, shape, tolerances, temper, finish, and mechanical properties. Sizes to ⅝-in. OD are produced in various tempers, finishes, and analyses. 12 pages. Posen & Kline Tube Co. Inc., Box 549, Norristown, Pa.

Circle 625 on Page 19

Lock Nuts

Complete line of spring-tempered steel lock nuts, including regular hex, integral washer, acorn, wing, and adjusting-nut types, is described and illustrated in Catalog 592. It gives details of design and locking principle, advantages, typical applications, dimensions, load ratings, materials, and finishes. 20 pages. Palnut Co., 75L Glen Rd., Mountainside, N. J.

Circle 626 on Page 19

Welcome . . .

. . . to Booth 2733-2735, 1960 Radio Engineering Show, New York Coliseum, March 21-24. A complete lion of sensitive relays.

SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1939)

Circle 480 on Page 19

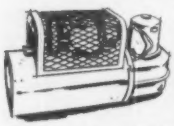
When you're choosing a protective coating...

HOW HOT IS YOUR HOT?

A Nose Cone Gets Hot

When conventional organic finishes were used in Chrysler Redstone Missile tests, they ignited and disintegrated under simulated re-entry conditions. Sicon survived because it possessed the inherent heat resistance to meet performance requirements. This has been confirmed in large scale tests and actual missile firings.

A Truck Heater Gets Hot



A porcelain type coating used on a truck heater failed because it could not stand the thermal shock of rapid heating and cooling. The same heating (550°-600°F.) and cooling left Sicon's film integrity unaffected.

A Tractor Engine Gets Hot

A farm equipment manufacturer used a bright organic red color on their standard equipment. The coating on the engine parts, which were subjected to high temperature, quickly decomposed. Midland engineers developed a matching bright Sicon Red which retained its color and gloss and protected the hot spots on the engine.

How HOT is your HOT?

Sicon possesses the flexibility of ordinary organic finishes and the heat resistance of ceramic coatings—up to 1000°F. in black or Aluminum; up to 550°-600°F. in decorative colors. Upon inquiry a sample Sicon formulation for testing your "hot" requirements will be prepared at no obligation. Send details of your "hot spot" problem today to Dept. 9-C.

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HEAT RESISTANT FINISH

A Silicone Product of

MIDLAND

INDUSTRIAL FINISHES COMPANY

WAUKEGAN • ILLINOIS

ENAMELS • SYNTHETICS • LACQUERS • VARNISHES

Circle 481 on Page 19

Cast-Bronze Alloys

Chemical and physical specifications of 29 cast-bronze alloys most widely used in the manufacture of sleeve bearings and bushings are compiled in a new brochure. Featured is a chart indicating compressive strengths of selected alloys and how these properties vary with thickness of metal. Comparative listing of latest military, SAE, Navy, Aeronautical, ASTM, and Federal specifications for the alloys is also included. 4 pages. Renewal Service Inc., 17th & Lehigh Avenues, Philadelphia, Pa.

Circle 627 on Page 19

Flexible-Shaft Assemblies

Circle Ess standard flexible shaft assemblies in over 180 variations are listed in Form 574. Assemblies are made up from stock components, offering savings in time and cost. Assemblies are particularly helpful for those needing a standard assembly quickly. 8 pages. F. W. Stewart Corp., 4311-13 Ravenswood Ave., Chicago 13, Ill.

Circle 628 on Page 19

Butterfly Valves

Iron-body, rubber-seated butterfly valves are for hydrostatic operating pressures to 125 psi and velocities to 16 fps. Bulletin 5904 includes data on construction and design, dimensions, directions for ordering, general hydraulic data, materials, and methods of operation. 36 pages. Darling Valve & Mfg. Co., Williamsport 28, Pa.

Circle 629 on Page 19

Control Panels

Selection of right control panel for a wide variety of automatic materials-handling systems is the subject of illustrated Bulletin G-9. Four basic types are illustrated and described, and a variety of applications is presented. Inside back cover is a chart of standard symbols used in graphic representation of electrical circuitry. Fuller Co., Catasauqua, Pa.

Circle 630 on Page 19

Ferrous Castings

Complete tabular summary of the engineering properties of various types of Meehanite castings available in industry is given in Bulletin 32. Twenty-four types of castings are available, produced under four classifications: General engineering, heat resisting, wear resisting, and corrosion resisting. 4 pages. Request on company letterhead from Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y.

Wafer Capacitors

Suited for printed circuit, modular, or encapsulated assemblies requiring high reliability are glass-dielectric wafer capacitors. Data sheet CE-1.02 describes capacitors as smallest currently available. 4 pages. Request on company letterhead to Corning Glass Works, Electronics Components Dept., Bradford, Pa.

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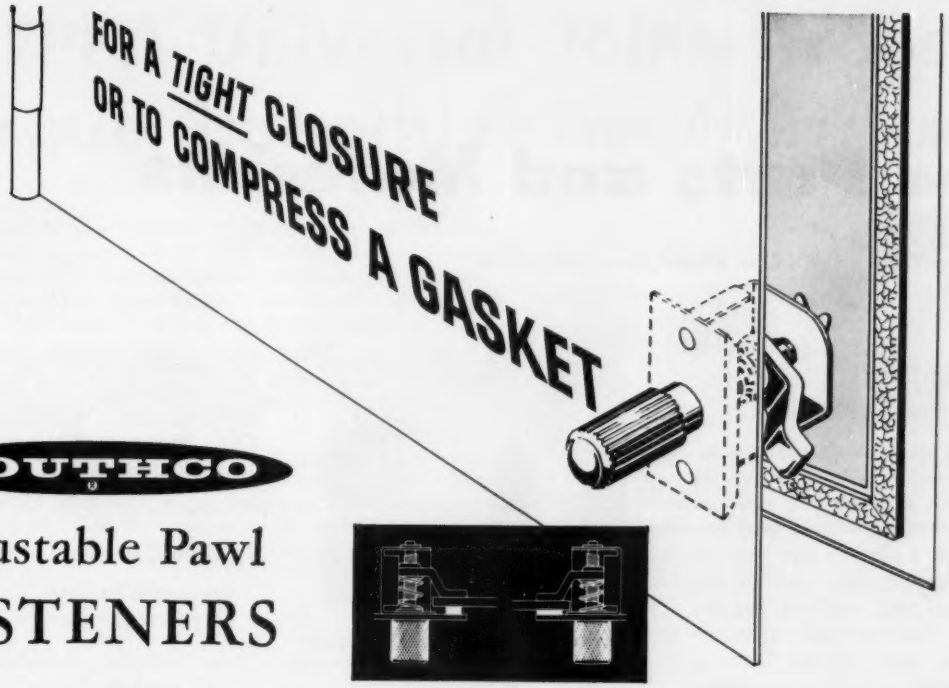
Circle 482 on Page 19

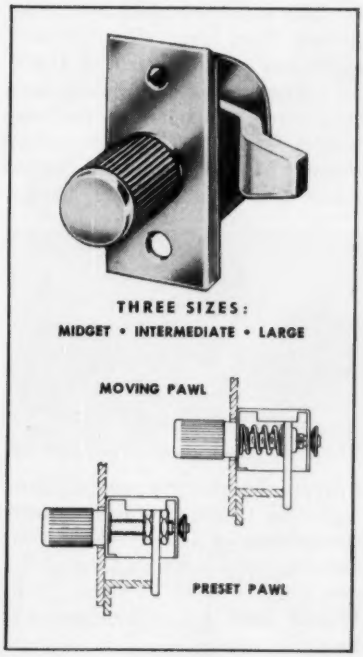
FOR A TIGHT CLOSURE OR TO COMPRESS A GASKET



SOUTHCO

Adjustable Pawl FASTENERS

¼ turn closes—additional turning tightens



Just slip the knob through a hole in the door (any door thickness—it doesn't matter). Fasten with two rivets, bolts, or welds. The Southco Adjustable Pawl Fastener will fit your door frame, even when material gauge varies between units.

Turn the knob. The first quarter turn latches the door. Now keep turning. You're pulling the door tightly against its frame. You can compress a gasket, form a dust or moisture seal, overcome vibration.

You'll save installation time and satisfy your customers with these rugged, attractive, pre-assembled fasteners. Ideal for heavy machines, electronic consoles, miniaturized units, cabinets, missiles, slide-mounted modules, etc.

FREE!
FASTENER HANDBOOK
Send for your free copy of Southco Fastener Handbook. Gives engineering data on many fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

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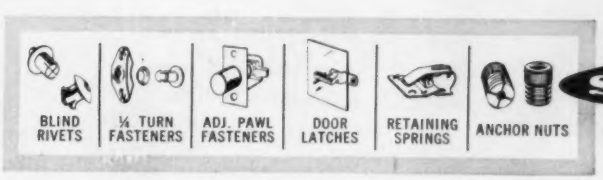


SOUTHCO FASTENERS

LION

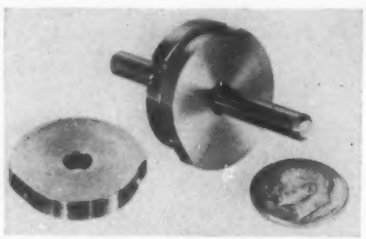
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Instrument Cams

feature dual rise

Adjustable instrument cam assemblies require less shaft space, yet provide two different rise rates on each cam. Feature of the two-cam assembly is ability to pair rises in three combinations: Two sharp, two gradual, and one sharp and one gradual. Two identical, stainless-steel cams make up the 5/16 in. thick assembly which has no mounting bushing, cams being mountable directly and independently on a shaft. Each cam has a sharp and a gradual rise for maximum versatility, and is also adjustable from 180 to 360 deg high and 0 to 140 deg low. Maximum radius of 0.5 in. and minimum radius of 7/16 in. permit 1/16 in. differential motion. Assembly has bores of 0.187 or 0.25 in. **Gap Instrument Corp.**, 116 E. Merrick Rd., Freeport, L. I., N. Y.

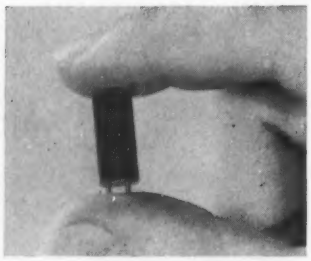


Circle 631 on Page 19

Overtemperature Protector

for subfractional-hp motors, small solenoids, transformers

Small inherent overtemperature protector, Klixon 5891, is designed specifically for subfractional-hp motors 1-in. diam and larger, and is equally suitable for small solenoids and transformers. Responsive to both current and temperature, protector is designed with a compensating heating element to ensure that snap-acting, disc-type sensing element will follow closely temperature changes of component to be controlled. Temperature levels of protection are 150, 175, and 200 C. Maximum contact capacity is 5 amp at 27 v dc or 120 v ac. Protector can be inserted into a cavity, secured to windings, or held by a clip. Envelope dimensions are 0.28 x 0.2 x 0.6 in., and weight, excluding leads, is 1 gram. **Spencer Products Group, Metals & Controls Div., Texas Instruments Inc.**, 34 Forest St., Attleboro, Mass.

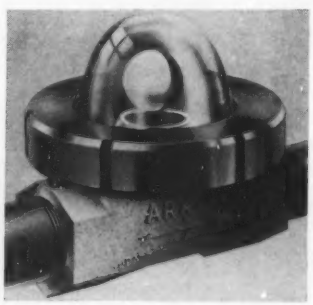


Circle 632 on Page 19

Flow Indicator

for very low flows has only one moving part

For flows down to 0.075 gpm water and ½ cfm air or gas, simple, reliable ball-type indicator shows at a glance whether flow is taking place. Ball, the only moving part, is located in toughened-glass dome and is visible during flow. If flow stops, ball drops out of sight. Arkon indicator is made in ½-in. pipe size for pressures to 100 psi with die-cast bronze body, and either nylon or Teflon ball. **Walker, Crosweller Div., McIntosh Equipment Corp.**, 15 Park Row, New York 38, N. Y.

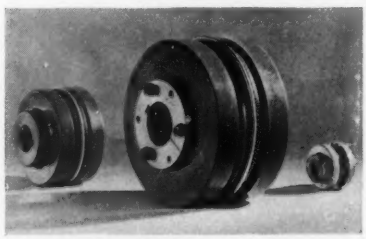


Circle 633 on Page 19

Flexible Couplings

low-cost units have only three components

Junior Sure-Flex couplings are furnished in three sizes: 3J, for stock bores from ⅜ through ¾ in.; 4J, for stock bores from ½ to 1 in.; 5J, for stock bores from ⅝ to 1⅛ in. Peak horsepower ratings, at 1750 rpm, are 1.5, 3, and 6 hp respectively. Low cost is obtained by casting flanges from zinc alloy AG40A, which has tensile strength of 41,000 psi. Simplified design incorporates only three components — two cast flanges and a one-piece rubber sleeve. Molded teeth of flexible sleeve lock into teeth of flanges without clamps or screws, tightening under torque to provide smooth transmission of power. There is no metal-to-metal contact. One of the new units is shown at right. **T. B. Wood's Sons Co.**, Chambersburg, Pa.



Circle 634 on Page 19

Self-Sealing Screws

for unlimited reusability are pressure tight

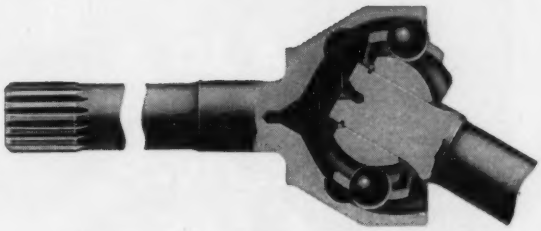
Uniseal captive self-sealing screws incorporate in screw head any Mil-

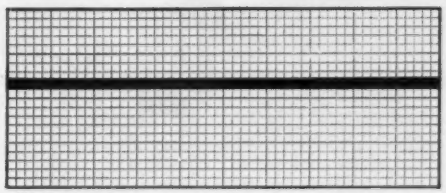
RZEPPA Universal Joints Transmit Torque Smoothly—*Even At High Angles!*

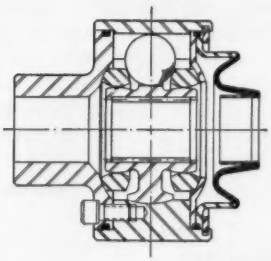
Rzeppa universal joints transmit 100% precision-smooth torque continuously—at angles of 35° and higher! Constant velocity action completely eliminates chatter, roughness and vibration. Size for size, you get longer shaft and bearing life, higher torque capacity with Rzeppa joints than with any other type!

The secret of Rzeppa's uniform power flow is that the driving balls are always in the bisecting plane of the driving and driven shafts. No matter what the shaft angle, torque flows evenly at constant velocity.

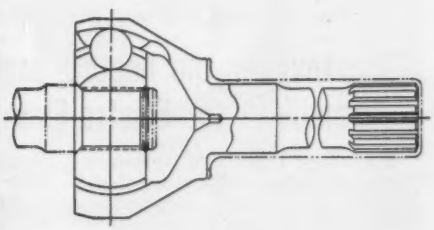
Rzeppa constant velocity joints are available in a wide variety of sizes, styles, angles and speeds. Rzeppa joints have been used successfully in equipment ranging from giant road-building and mining equipment to the most intricate aircraft and missile applications.



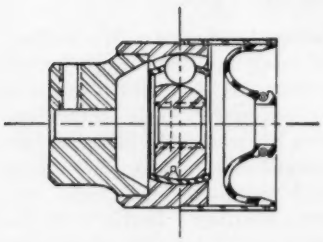




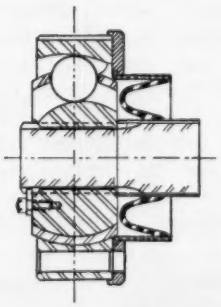
"MX" Type CV Joint (⅞" to 3½" swing diameter) . . . designed primarily for high speeds, low angles . . . blowers • compressors • servo motors • pumps • control devices • frequency converters • missiles • aircraft • dynamotors



Bell-Type CV Joint (15/16" to 2½" axle shaft diameters) . . . designed for high-angle driving steering axles used in road building machinery • mining machinery • industrial • automotive applications



"OV" Type CV Joint (2⅛" maximum swing diameter) . . . designed for smaller applications . . . ordnance • machine tools • servo mechanism • farm equipment • automotive equipment



Disc-Type CV Joint (from 2⅛" to 16¼" swing diameter) . . . designed for all types of industrial drive applications where constant velocity and trouble-free service are required.

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for this new engineering data folder on the complete line of Rzeppa constant velocity joints. No cost or obligation to you.

Please send my copy of Con-Vel's NEW engineering data folder on CV universal joints.

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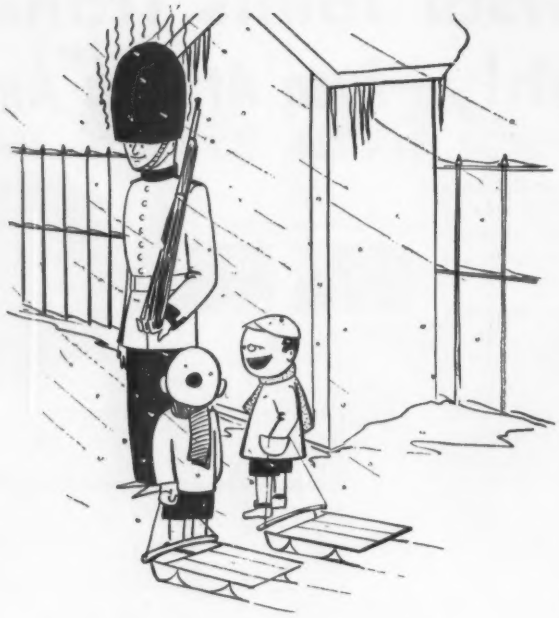
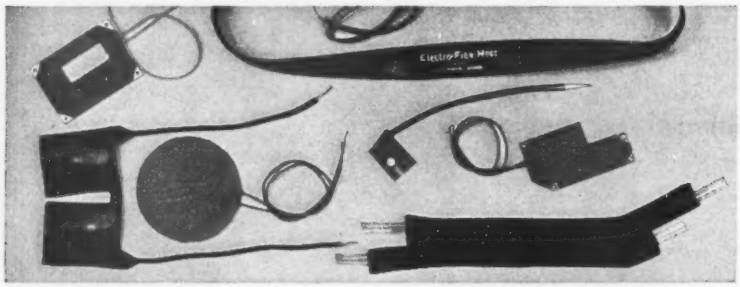


"Blimy, why should 'e get cold? He's got a 'eating h'element in 'is bonnet."

The tougher the heating problem, the better the opportunity for Electro-Flex Heating Elements

For every ridiculous application you can think of there are thousands of practical ones where Electro-Flex heating elements can lick a cold problem. Opportunities are endless. Electronic and mechanical equipment can be made operable, resin cements and plastic laminates can be heat cured, aircraft surfaces can be de-iced, drains defrosted, instruments protected—just to name a few examples.

Electro-Flex has the reputation for solving difficult heating problems better and faster. Engineering is in the hands of experienced heating experts. So, what is your heating problem? Send us the specifications of the application or contact our engineering department for further information.



Any size, large, small or very thin.
Lightweight, tough or flexible.
High voltage tested.

Resist corrosion—Immersible.
Insulated with silicone rubber, neoprene, Kel-F Resin, Polyethylene, etc.

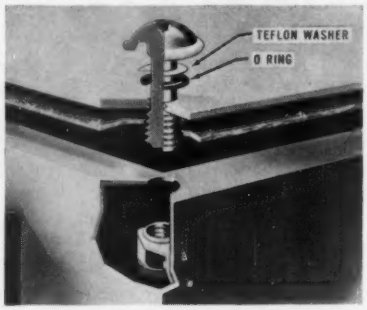
Standard units available.
Operate under high pneumatic pressure.
Meet USAF Specs.

send for free illustrated booklet

Electro-Flex Heat, INC.

83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)

"FIRST with STANDARD ELEMENTS"



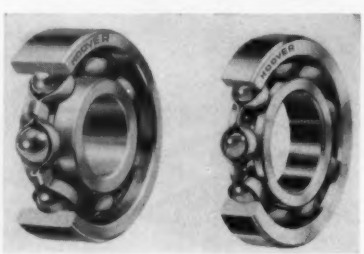
spec O-ring, lubricated to prevent inadvertent galling or cutting by a thin Teflon washer. Metal-to-metal contact is maintained at all times, assuring maximum tension and leakproof seal against a variety of media, temperatures, and pressures. Lightweight and economical, screws provide a positive seal, and a minimum of radio-frequency leakage in electronic equipment without use of additional surface sealants or combersome closure methods. **Aero Bolt & Screw Co. Inc.**, 1071 W. Arbor Vitae, Inglewood, Calif.

Circle 635 on Page 19

Ball Bearings

in inch or metric boundary dimensions

R-series bearings (right) facilitate shaft and housing design because all boundary dimensions are made to convenient inch dimensions. Series is compactly designed and proportionally similar to conventional extralight and light series metric bearings. Bearings are furnished in 15 sizes for shafts from $\frac{1}{8}$ to $1\frac{1}{2}$ in. diam. Series 30 ball bearings (left) fulfill the need for extrasmall metric ball bearings for use with shafts and housings of small diameter. Bores range from 4 to 9 mm in diameter, smaller than conventional extralight, light, and medium series. All bearings of both series are available either open or shielded. Series 30 bearings can



Circle 485 on Page 19

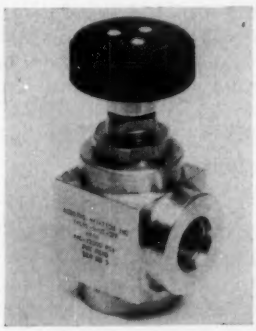
also be equipped with a single or double seal. **Bearing Div., Hoover Ball & Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich.

Circle 636 on Page 19

Pressure-Balanced Valves

for pressures to 12,000 psi

Series 400 valves are suitable for acids, gases, fuels, corrosive chemicals, and oxygen. Easily operated, pressure-balanced units with unique sealing features are for service to 12,000 psi. All functional parts are stainless steel, in a stainless-steel



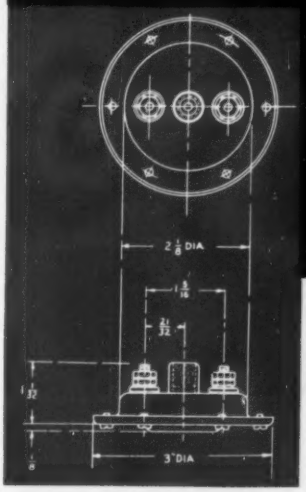
forged body. Seals are self-energizing and automatically compensate for wear. Valves are for panel mounting and can be completely serviced from front of panel without disturbing line connections. Nonrotating valve spindle reduces wear and prevents galling. No moving O-rings are used. Standard valve is for temperature range of −65 to +250 F with ½-in. diam flow passage and ¾-in. tube ports. **Robbins Aviation Inc.**, 2350 E. 38th St., Los Angeles, Calif.

Circle 637 on Page 19

Photoelectric Scanner

operates on reflected light

With energy source and detector combined in a single unit only 2¼ in. long by 1⅛ in. diam, Type SA-IR infrared photoelectric scanner responds to metallic and nonmetallic objects. It provides a simple and easily installed means for handling a variety of counting and control operations. Unit senses objects or control areas at distances up to 2 in. Infrared source is rated at 60,000 hr life when operated at 5 v ac. Solid-state detector is sturdy,



A pressure switch that's completely reliable, at a surprisingly low cost. Easy to install, easy to connect. Applicable to dozens of uses. UL approved, of course.

- Steel (cad plated) housing, brass terminals.
- Set at factory to close at ½" to 15" H_2O.
- Compact, weighs only 5 oz.

Your inquiries are invited!

McQUAY-NORRIS MANUFACTURING CO.
ELECTRIC PRODUCTS DIVISION
2320 Marconi Ave., St. Louis 10, Missouri

50 YEARS IN THE MANUFACTURE OF PRECISION PRODUCTS

Circle 486 on Page 19

CAUSTIC SOLUTION

A CASE IN POINT—This is a 19 pound Ni-Resist valve body designed to handle caustic fluids at 400 psi. It was cast for the John Bean Division of Food Machinery & Chemical Corp. Ni-Resist is ideal for this application because it combines high corrosion resistance with superior resistance to erosion from high velocity fluids.

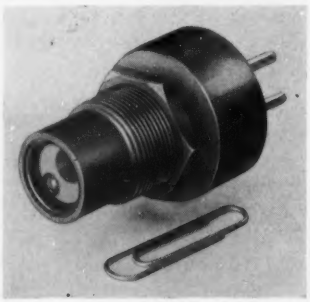
The intricate coring required demands unusual skill to produce Ni-Resist castings leak-proof at 400 psi operating pressures. Hamilton Foundry succeeded in producing pressure tight castings, an accomplishment difficult for the best of foundrymen.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491



sensitive, and sealed for protection against moisture, dust, or corrosive atmospheres. Standard, four-prong base permits plug-in connection to the control circuit. **Farmer Electric Products Co. Inc.**, 2300 Washington St., Newton Lower Falls, Mass.

Circle 638 on Page 19

Miniature Glow Lamps

have high brightness

LNE 45, 47, and 48 miniature glow lamps are five times brighter than the lamps after which they were patterned without changing physical characteristics of the basic lamps. New glow lamps operate at ½ w on 105-125 v ac instead of ¼ w and have a series resistance of 12,000 ohms instead of 30,000 ohms in basic lamps. Units can be used in high ambient light applications without losing ruggedness of standard neon lamp. **Signalite Inc.**, Neptune, N. J.

Circle 639 on Page 19

Plastic Sockets

are unaffected by oils and greases

Two plastic sockets for casters are available for use on mobile appliances, furniture, and office equipment. Sockets are superior to comparable metal sockets in long-wearing qualities, ease of swiveling, resistance to static loads and impact

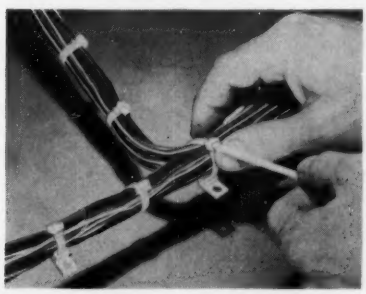
shocks, freedom from rust, and reduction of noise. They are unaffected by lubricating oils and greases, resist alkalies and organic solvents. Designated No. 701 and No. 702, sockets are for use with X-Series casters with 7/16-in. stems. No. 101 fits tubing with 0.58 to 0.591-in. ID, and No. 702, with ribs, fits tubing with 0.628 to 0.639-in. ID. **Faultless Caster Corp.**, Dept. PR-170, Evansville 7, Ind.

Circle 640 on Page 19

Band Clamp

now has separate mounting tab

Wedge Lock band clamp, designed to simplify and speed up wire, cable, tubing or hose bundling, is now available with a separate mounting tab. Tab can be premounted at support points to simplify planning, and band clamp and wiring can then be added later. Or, tab can be



slipped on its clamp when cables are bundled in advance and entire assembly mounted at once. All-nylon band clamp, used by itself or with mounting tab, provides permanent, vibrationproof holding action. One size band clamp accommodates cable or wire diameters from 1/8 to 1¾ in. **Weckesser Co.**, Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill.

Circle 641 on Page 19

Proximity Limit Switch

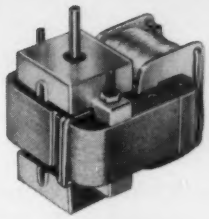
resists coolants, dirt, and abrasive dust

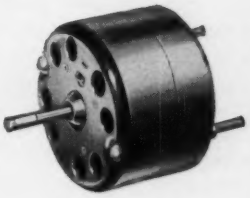
Gemco proximity limit switch is entirely self-contained in a 6¾ sq-in. hermetically sealed brass housing. It is impervious to coolants, abrasive dust, dirt, or temperatures from −50 to +250 F, and is unaffected by anything other than very strong external magnetic fields. Switch

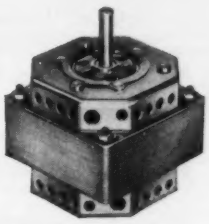
WHISPER QUIET!

THE MOST EFFICIENT, THE MOST RELIABLE MOTORS MONEY CAN BUY

The unexcelled performance of GI motors together with the unusually low sound level means extra care and control in every step of design and manufacturing — and extra dependability in day-in, day-out operation. That's why, for 40 years, the great names in industry have preferred to rest their reputation on GI motors. GI produces a "Smooth Power" motor for every sub-fractional hp requirement — including yours. Write today for complete full-line catalog.







Smooth Power AC MOTORS

1/1800 H.P. TO 1/35 H.P.

General Industries' standard line of motors is adaptable, with slight variations, to literally thousands of applications.

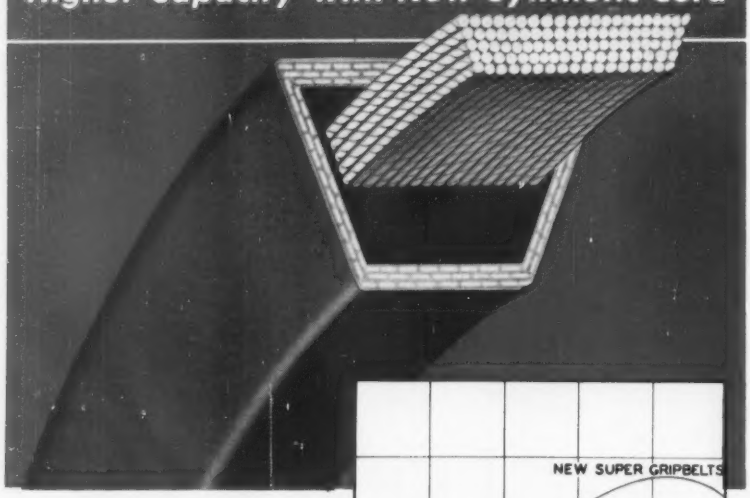
THE GENERAL INDUSTRIES CO.

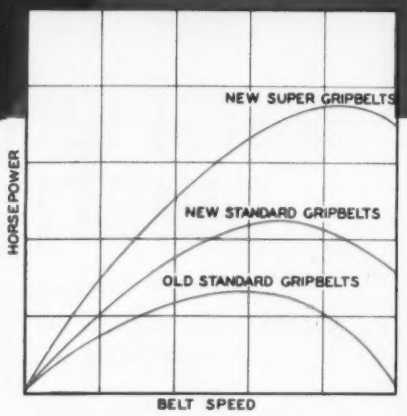
DEPT. GK • ELYRIA, OHIO

Circle 488 on Page 19

Browning SUPER GRIPBELTS

Higher Capacity with New Synthetic Cord



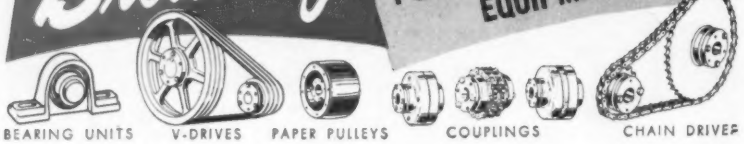


Extensive tests over a three-year period indicate that the synthetic strength member now used in Browning Super Gripbelts provides capacities and length stability far beyond those of any vegetable or synthetic cord previously devised. Together with other recent improvements in materials and design, this high strength cord improves performance and completely obsoletes former horsepower ratings. Advantages:

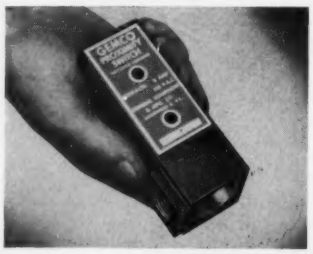
- Capacities increased as much as 2¼ times previous standard Gripbelts
- Narrower drives, fewer belts; more compact design, lighter weight
- Lower costs for both original equipment and maintenance
- Standard size sheaves and belts. Existing inventories cover full hp range
- Available NOW from distributor stocks, coast to coast

Browning *Standard* Gripbelts have been increased in similar proportion, to today's realistic ratings as indicated in the chart above. We'll be glad to tell you more about the advantages of Browning Gripbelts, both Standard and Super. Ask your near-by Browning distributor for complete information and literature or write direct to **Browning Manufacturing Company, Maysville, Kentucky.**

Browning POWER TRANSMISSION EQUIPMENT



BEARING UNITS V-DRIVES PAPER PULLEYS COUPLINGS CHAIN DRIVES



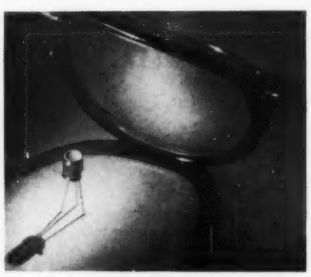
operates without transistors, tubes, coils, relays, or amplifiers. It requires no power input and operates completely without physical contact with its actuating means. Switch consists of an armature carrying a set of silver contacts disposed within the field of enclosed permanent magnets. Normally closed contacts are positively held closed by force of magnetic field. When a ferrous part is brought into sensing area of field, armature snaps contacts to other position to close normally open contacts. It remains in that position until part is removed from sensing area. Switch is not subject to mechanical failure or environmental limitations, and operates at high speed. **General Equipment & Mfg. Co., Dept. TP, Louisville 2, Ky.**

Circle 642 on Page 19

Tunnel Diode

has peak-to-valley current ratio of 5:1

New tunnel diode, a 1000-megacycle device, achieves higher frequency operation more easily than the transistor. It is relatively insensitive to temperature changes and nuclear irradiation, and is expected to effect important space and capability improvements in computers, television sets, communication equipment, nuclear controls, satellites, and space vehicles. Features of diode include a minimum peak-to-valley current ratio of 5:1, and typical peak-point current rating of 1 ma, held to ±10



Flange diameter: 106 inches

No less impressive: body diameter is 96 inches, and bore diameter is 75 inches. This main cylinder stands 115¾ inches high, and weighs 103,300 pounds. Made of molybdenum-vanadium steel, we heat-treated and tested it before shipping to our customer. By now, it's been finish-machined and is hard at work in a hydraulic press.

Incidentally, the same order called for three other cylinders, one bolster, and four tie rods. These pieces ranged in weight from 22,000 pounds to 113,000 pounds. Bethlehem forged and machined them all as specified, and delivered them on time.

RIGHT ON THE NOSE. Our shops will meet your specifications *exactly* on all types of press, drop, and hammer forgings, regardless of size or design.

BETHLEHEM STEEL COMPANY BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

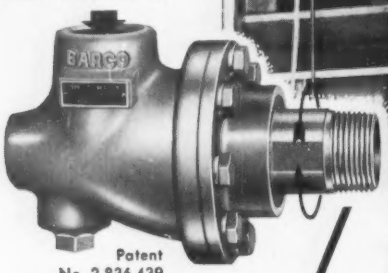
BETHLEHEM STEEL

Circle 490 on Page 19

OUTSTANDING PERFORMANCE

BARCO ROTARY JOINTS

Shown at the right is an installation of ¾" Barco Type C Rotary Joints on a 9" dia. calender roll stack. Every other roll is equipped to be steam heated and syphon drained at 125 p.s.i., 300°F. The rolls run at a paper speed of 1300 FPM, or approximately 450 RPM. The joints have been in service for many months with no difficulties experienced.



Patent No. 2,836,439

TYPE C

Single Flow or Syphon Flow

- **RESISTS SEAL RING BREAKAGE**—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.
- **WIDE SPACED BEARINGS**—Two, instead of one . . . increased bearing area. No lubrication required. Lowest friction.
- **200 P.S.I. STEAM RATING**—Heavy duty service at *no extra cost*. Eight sizes, ⅛" to 3".

SEND FOR CATALOG 310

HERE is another case (*above installation*) where an experienced user of rotary joints made comparative tests. Two other makes of joints were tried and Barco selected.

"*Last longer without maintenance!*" reports the user. When properly installed, Barco Joints easily withstand rugged service on paper calenders, machines, and other mill equipment.

Barco Type C Joints are available from LOCAL STOCKS throughout the country. Standard series joints handle all steam pressures to 200 psi—one basic style for all services, single flow or syphon flow. *Type CF offered for journal flange connections. ASK FOR INFORMATION.*

FOUNDED 1908 BARCO PRODUCTS BACKED BY EXPERIENCE

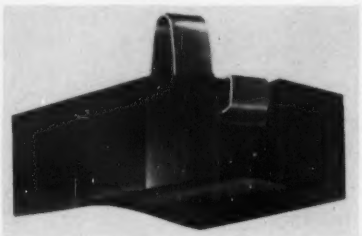
BARCO MANUFACTURING CO.
506D Hough Street, Barrington, Illinois
The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints
In Canada: The Holden Co., Ltd., Montreal

per cent. Hand-made laboratory samples are presently available. Diode is packaged in TO-18 standard transistor housing, and is rated for an operating junction temperature of −55 to +100 C. Semiconductor **Products Dept., General Electric Co.**, Charles Bldg., Liverpool, N. Y.

Circle 643 on Page 19

Rubber Clips

for assembly and fastening uses



Bumpers for assembly and fastening applications, designated Cooper Clips, consist of a rubber extrusion and a spring-steel clip which positively retains the rubber, in addition to acting as a fastener for entire unit. Applications include feet, bumpers, shock absorbers, vibration dampeners, and insulating devices. Applications are successful under both static and dynamic loads. **Industrial Rubber Products Div., Cooper Tire & Rubber Co.**, Dept. 3-B, Findlay, Ohio.

Circle 644 on Page 19

Universal Motors

have high operating speeds and starting torques

Three standard stock models of series-wound universal motors complete a line of 17 units in the 1 to 1/50-hp range. Characteristics include high operating speed and starting torque, adaptability to speed control, and light weight per horsepower. Open continuous rat-

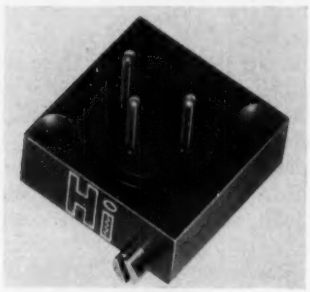
ings of the three models are ½ hp at 5000 rpm, ¾ hp at 7500 rpm, and 1 hp at 10,000 rpm. All three are built in frame size 4334, have pad-type bases, length of 8⅞ in., width of 5¾ in., and height of about 5½ in. Standard motors, built in aluminum housings, operate on 115 v dc to 60 cycles ac and are nonreversible, rotating counterclockwise at commutator end. **Universal Motor Div., Robbins & Myers Inc.**, Springfield, Ohio.

Circle 645 on Page 19

Trimming Potentiometer

subminiature unit is ½ in. wide and 0.2 in. thick

WeeTrim subminiature potentiometer has a square aluminum housing and weighs less than 2 grams. It is ½ in. wide and 0.2 in. thick. Every resistance turn is locked in position and bonded to mandrel for high wiper tension. Method of winding provides lower noise, repeatability, and permanence of wiper position for a given adjustment of lead screw. Other characteristics include: Standard resistance values of 10 to 50,000 ohms; continuous rotation of wiper; temperature range of −55 to +200 C; vibration, 30 g at 10 to 200 cps; shock, 50 g for 11 mu sec duration; and altitude, 50,000 ft. Unit meets MIL-E-5272A. **Handley Inc.**, 12960 Panama St., Los Angeles 66, Calif.



Circle 646 on Page 19

Spring-Steel Nuts

are low-cost, quality units

Crest-Nuts, made of heat-treated spring steel, have dimensions of ⅛ in.-27 NPS, hex width, 9/16 in., washer diameter, ⅞ in. The low-cost, quality nuts are available cad-

BALDOR
Streamcooled MOTORS

For general use or for specific applications demanding the most exacting requirements, the Baltric line of motors more than fills the bill. One reason is the "Monocast" Stator shown above.

Steel laminations in an aluminum alloy casting form a stator frame of greater stability . . . greater rigidity. This permits the use of a new and better slot design. The result is uniform magnetic flux distribution throughout the motor—gives more power, greater efficiency, higher power factor and quieter operation.

If you're interested in getting top efficiency from your equipment while holding costs to a minimum, investigate the Baltric line of motors—without obligation! Just write . . .

BALDOR
ELECTRIC COMPANY
4349 Duncan Avenue • St. Louis 10, Missouri

Over 500 Authorized Sales & Service Distributors in U. S. A.

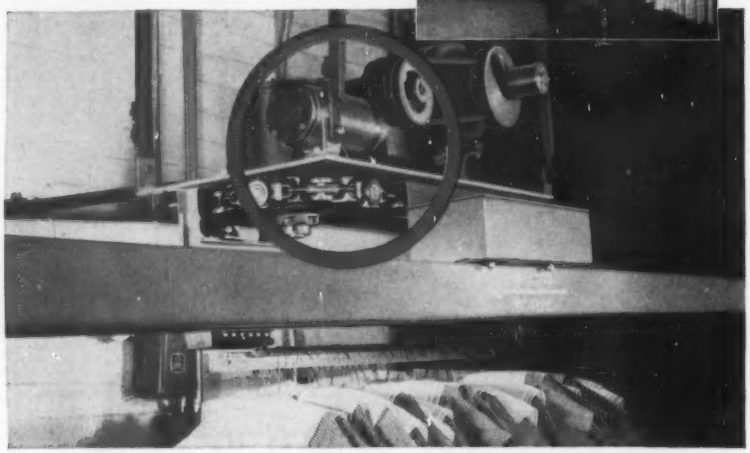
District Offices: Atlanta • Chicago • Cleveland • Dallas • Dayton • Des Moines • Detroit • Litchfield, Conn. Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • Kansas City, Mo. Oakland • Philadelphia • Portland, Ore. • Syracuse.

Circle 492 on Page 19

a CM Power-Flex Conveyor using a WINSMITH Speed Reducer

"DELIVERS THE GOODS" FOR MONTGOMERY WARD

WITH THE POWER-FLEX SYSTEM, Montgomery Ward handles all women's and children's garment requirements for more than 500 retail stores. Each of these trolleys can carry 50 garments or a maximum load of 200 lbs.



A CLOSEUP of the Winsmith Model 5 CVD Speed Reducer used to drive the CM Power-Flex Conveyor which features Telematic Dispatch Control. Chain Speed is 40 ft/min.

MONTGOMERY WARD'S DISTRIBUTION CENTER on Varick Street in New York City, is built around a Columbus McKinnon Power-Flex Conveyor System equipped with a Winsmith Speed Reducer. CM's Power-Flex is a power and free system that, in this application, handles as many as 38,000 women's and children's garments in a single 8-hour day. Its advanced design and construction features permitted savings of 50,000 sq. ft. of floor space and untold dollars in operating economies.

COLUMBUS McKINNON specifies Winsmith Speed Reducers for their Power-Flex Systems because high output efficiency, compactness, long service life, minimum maintenance and low initial cost are prime factors.

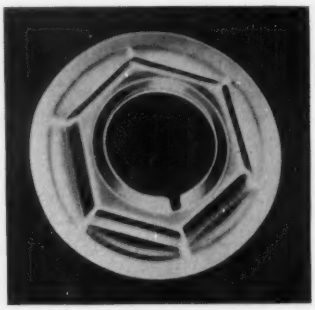
FOR EVERY APPLICATION from 1/100 to 85 H.P.—in ratios from 1.1:1 through 50,000:1—investigate the advantages of standardizing on Winsmith Speed Reducers for your products.

WINSMITH SPEED REDUCERS

WRITE TODAY... for complete selection information and engineering data.

WINSMITH, INC.

16 Elton Street, Springville, (Erie County), N. Y.



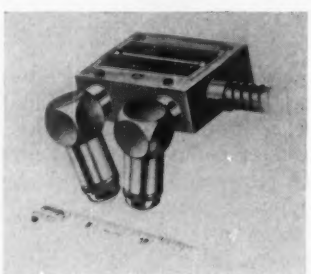
mium plated, nickel plated, black phosphated, and plain. **Crest Products Inc.**, P. O. Box 64, Union, N. J.

Circle 647 on Page 19

Reflector-Type Pickup

is self-contained, adjustable unit

Model RFU-7 reflecting-type pickup is a compact, self-contained, adjustable unit for use with various controls and counters. Position of light source and photo unit is adjustable for angle and reflection of spot distance. IRC series of relays contain the controls for adjusting light sensitivity and photo sensitivity in the pickup. With these controls, relay is triggered to act at any desired threshold of reflected light. Wide variety of applications includes inspecting, sorting, counting, control for the difference in reflected light, and differentiating accept-



able and reject conditions. Small size of unit permits installation in machines where space is limited. **Photomation Inc.**, 96 S. Washington Ave., Bergenfield, N. J.

Circle 648 on Page 19

Ball-Bearing Slides

in slide widths from 5/16 to ½ in.

Ultrathin Series 140 and 150 ball-bearing chassis slides are designed

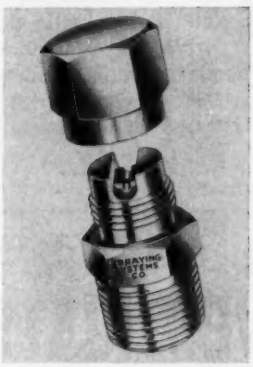
Circle 493 on Page 19

for applications requiring instant accessibility of electronic consoles for maintenance, or pushbutton interchange of rack-mounted chassis. Slide mechanisms are of extruded 7075 T6 aluminum alloy, with precision broached ball races. All other components are stainless steel. Load rated at up to 200 lb per pair, slides are available in widths from 5/16 to ½ in. Tilting mechanisms permit 90 deg upward and downward swing of chassis for servicing ease. Positive locking of slide assembly in fully extended position is provided. **Jonathan Mfg. Co.**, 720 E. Walnut, Fullerton, Calif.

Circle 649 on Page 19

Descaling Nozzles

permit use of shut-off cap



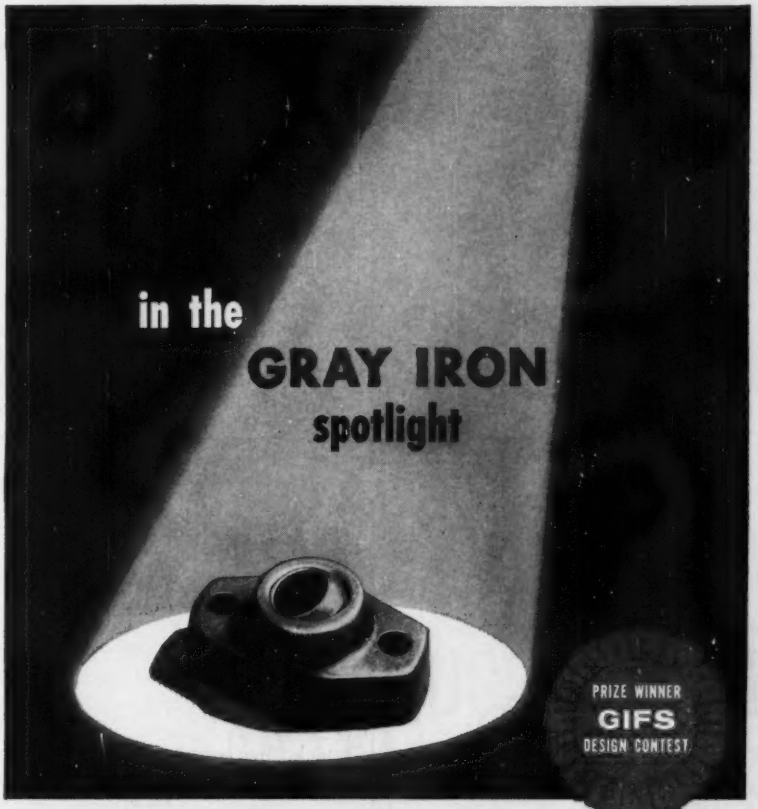
Descaling nozzles are available with external threads on outlet end of body. Stainless-steel caps are supplied for capping any nozzles in a manifold that are to be shut off. Use of nozzles and caps results in material water saving when rolling narrow strips. Nozzles are stainless steel with tungsten-carbide orifice inserts, providing maximum possible resistance to abrasion. Slot-type strainers are supplied as optional equipment. **Spraying Systems Co.**, 3274 Randolph St., Bellwood, Ill.

Circle 650 on Page 19

Magnesium Boxes and Covers

are deep-drawn units

Magnesium boxes and covers are deep-drawn, in sizes from 1½ x 1½ in. and height from 7/16 to 1¼ in., to 18 15/16 in. × 18 15/16 in.



"Ready to go" Gray Iron Casting saves Oliver Corporation 80%

The Oliver Corporation, leading farm implement manufacturer, reduced costs 80% by converting a swivel fastener from a multiple-piece part to a single iron casting. Using gray iron's unique ability to be cast in an intricate shape as one part, *as well as around a movable ball bushing,* Oliver eliminated all assembly and welding operations. The ball is coated with a precise thickness of refractory so that when the iron is cast around it and the refractory removed, the ball is firmly held but free to move. You, too, can eliminate costly in-plant operations. Design your products "ready to go" with your GIFS foundry engineer. Through association with nearly 400 foundries, he has acquired a broad fund of knowledge to help improve your product.

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

Specify Modern GRAY IRON CASTINGS

Made by Informed Foundrymen!

Circle 494 on Page 19

put HEINZE in your designs

HEINZE UNIVERSAL MOTORS

HIGH TORQUE FOR ELECTRIC CAN OPENERS

. . . hand tools . . . gum tape machines . . . vending machines . . . meat slicers . . . automobile antennas . . . and similar applications requiring high starting and/or running torque.

In addition, Heinze Universal Motors are rugged to withstand tough applications, compact to fit limited space, versatile to allow all types of mounting arrangements and modifications, uniform in quality, keyed to high production, and are competitively priced.

Standard voltage rating is 115V AC/DC but motors are supplied for other voltages.

SEND COUPON FOR CATALOG

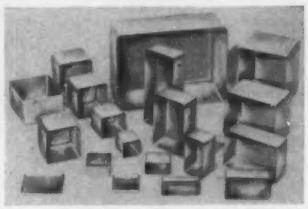
HEINZE ELECTRIC COMPANY
685 Lawrence Street, Lowell, Mass.
SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

Heinze Electric Company
685 Lawrence Street, Dept. D
Lowell, Massachusetts

Please send catalog on Heinze Sub-Fractional Horsepower Motors and Blowers.

Name and Title.....
Company.....
Street and Number.....
City and State.....

Circle 495 on Page 19



with height from 2 to 9 in. Any box can be furnished in any increment of 1/16 in. Surface of boxes is wrinklefree and requires no special preparations. **Zero Manufacturing Co.**, 1121 Chestnut St., Burbank, Calif.

Circle 651 on Page 19

FEP Fluorocarbon Resin

for continuous service at 400-F temperatures

Teflon 100 FEP-fluorocarbon resin can be extruded or molded in thermoplastic processing equipment. It is virtually immune to chemical attack, has excellent electrical insulating, antistick, and frictional characteristics, and will not absorb moisture. Resin is rated for continuous service at temperatures to 400 F and at higher temperatures for limited periods of time. Low temperature is −450 F. Specific uses include jackets for coaxial and multiconductor cable, aircraft wiring, molded electronic components, laboratory tubing, and chemical equipment linings. Material is furnished in natural color only. **E. I. Du Pont de Nemours & Co.**, Public Relations Dept., Wilmington, Del.

Circle 652 on Page 19

Snap-Acting Switch

provides DPDT control in a single unit

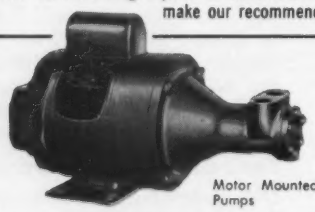
With two basic Type-A snap-acting switch mechanisms contained in a single housing and actuated by same operating button, Type DA switch provides a compact, flexible, low-cost means for controlling electric circuits in automatic devices. DPDT switch features quick-connect terminals for snap-on wiring, and excellent resistance to dirt, dust, and moisture. In addition to basic,

WANT QUALITY AT SAVINGS ON ORIGINAL EQUIPMENT PUMPS?

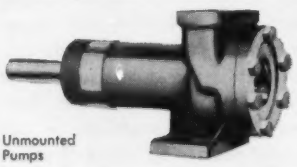
If you manufacture machines that require pumps, it will pay you to learn how a Viking rotary pump can save you money while adding quality to your equipment. Viking specializes in these four types of rotary pumps—sizes ⅔, 1½, 3½ G.P.M. and larger to fit your needs. We have high production runs of interchangeable parts made with custom design skill, effecting substantial savings and assuring top quality.

INVESTIGATE VIKINGS

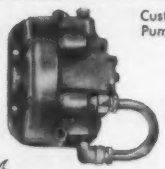
Just give us the opportunity of figuring with you on your pumping requirements. We will combine long experience on thousands of cases with creative engineering ability to make our recommendations.



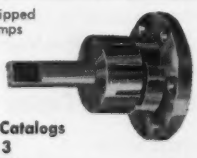
Motor Mounted Pumps



Unmounted Pumps



Custom-built Pumps

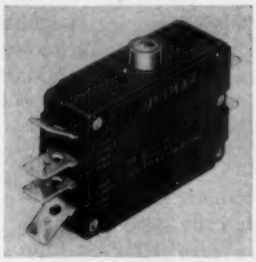


Stripped Pumps

Send Today for Catalogs BH, Page 3 and SP-509H

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, It's "ROTO-KING" Pumps
Offices and Distributors in Principal Cities • See Your Classified Telephone Directory

Circle 496 on Page 19



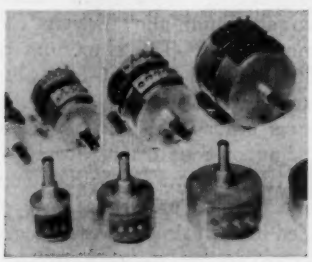
pin-actuated model, switch can also be furnished with leaf, roller-leaf, hinged, and overtravel-plunger actuators. Molded phenolic body is 1⅛ in. high, 1 13/16 in. long, and 41/64 in. thick; mounting is by two screws on 1-in. centers. Ratings are: 15 amp, 125/250 v ac; ½ hp, 125 v ac; 1 hp, 250 v ac; ¾ hp, 125 v ac; 1½ hp, 250 v ac. **Unimax Switch Div., W. L. Maxson Corp.**, Ives Road, Wallingford, Conn.

Circle 653 on Page 19

Precision Potentiometers

for panel controls

Two series of precision potentiometers fulfill requirements for military and commercial applications. TP series, shown, all single-turn, rotary, wirewound types, provide maximum durability and reliability under severe environmental conditions imposed on equipment in military installations. Stops are ruggedly constructed and withstand 8 lb-in. torque, essential for panels operated in extreme temperatures by heavily gloved hands. TP series ranges in size from ½-in. subminiature to 2-in. diam unit. MTF series includes three types which are physically alike in size and shape, differing only in the number of turns necessary to traverse the resistance element. Three, five, and ten-turn models afford infinite resolution. Designed especially for linear functions, MTF potentiometers have metallic film capsule con-



Circle 497 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

–BEARINGS of smooth, tough DuPont NYLON

Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

COST LESS to BUY
COST LESS to INSTALL
& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
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- DAMP VIBRATION
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- RESIST ABRASION
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- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

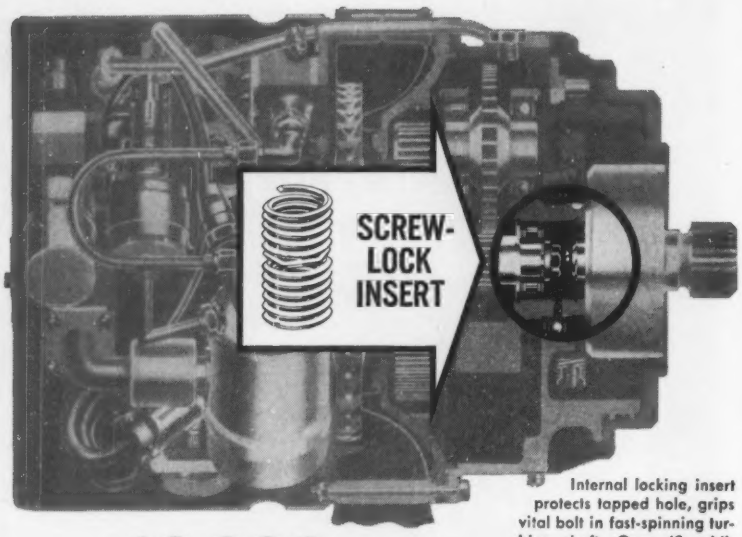
NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* Inserts insure threaded fastener security throughout the starter.

at 46,000 R.P.M.

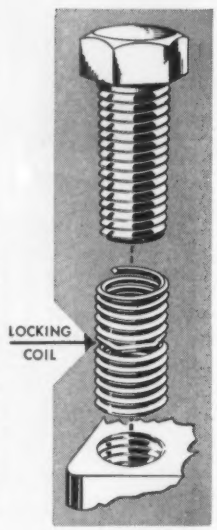
HELI-COIL®

SCREW-LOCK INSERT*

holds this vital bolt fast
...Without Lock Washers
or Lock Wiring!

Even when the turbine shaft of General Electric's new AS-18 turbostarter whirls at 46,000 rpm... the key bolt at the end of the shaft can't work or wear loose. General Electric puts a one-piece, *internal locking* ***Heli-Coil*** Screw-Lock Insert in this tapped hole, gets thread security in this important threaded assembly despite vibration met at high shaft speeds.

In addition to the critical shaft application, General Electric uses more than 40 of these ***Heli-Coil*** stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring... lighter weight... less installation cost... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of ***Heli-Coil*** Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

***Heli-Coil* Screw-Lock Inserts**

- positively lock screws and bolts against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes
- save assembly time, space, weight and cost
- meet military specs for locking torque and vibration

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION*, 503 *Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-Lock Inserts
NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____ 1772

In Canada: Armstrong Beverley Engineering Ltd., 6975 Jeanne Mance St., Montreal 15, Que.

Circle 498 on Page 19

struction, providing extremely long wear and immunity to moisture or foreign particles. **Technology Instrument Corp.**, Acton, Mass.

Circle 654 on Page 19

Zone Control Valve

is motorized unit in four body types

Hydrozone motorized valve is for use on hydronic heating and cooling systems and for steam up to 10 psi. Valve features four body types for varying job conditions. It has visual valve-stem indicator, and is easily set for manual operation in case of power failure. Viton O-ring eliminates leaking at valve

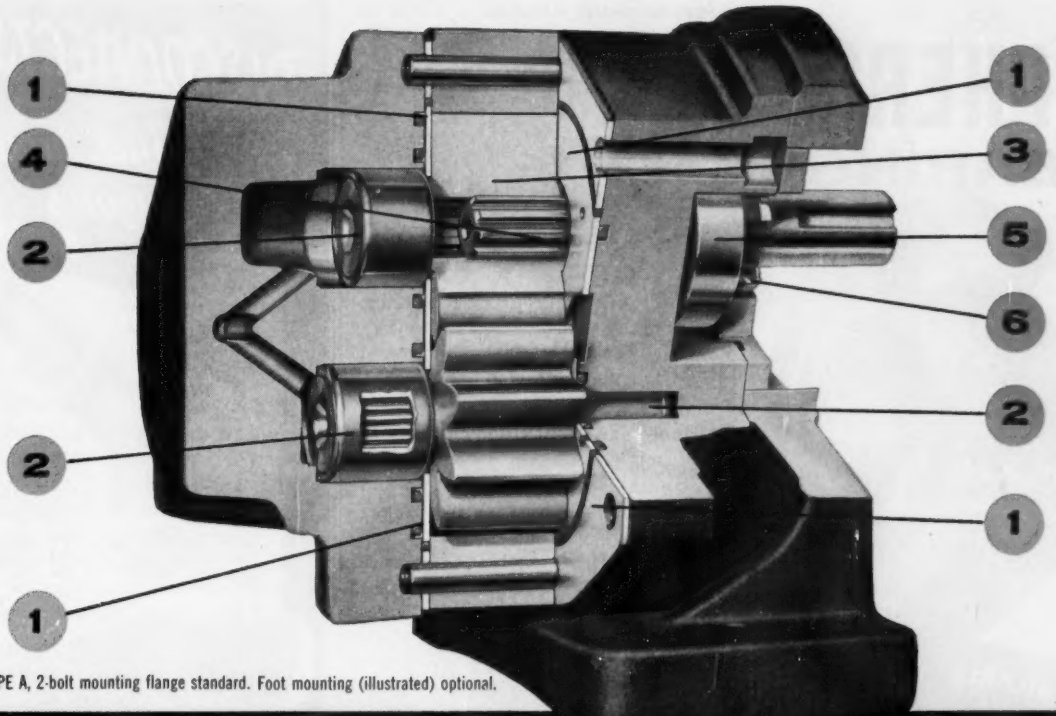
stem. Valve has 100 per cent shut-off feature, allowing it to be used on low-pressure steam systems. Angle-body pattern allows flow through valve in any direction. Bodies are all bronze. Valve is currently available in ¾-in. size, with 1 and 1¼-in. sizes soon available. Maximum temperature of liquid accepted is 250 F. **Cash-Acme**, P. O. Box 191, Decatur, Ill.

Circle 655 on Page 19

Blind Rivets

in aluminum alloy

Line of mechanical lock-spindle, self-plugging blind rivets includes two aluminum-alloy designs. Fasteners of 2024-T36 aluminum pins with 2117-T4 or 5056-HI4 aluminum sleeves are now available. Fasteners are available in either protruding or countersunk head styles in ⅛, 5/32, and 3/16 in. nominal diam. Broad grip ranges are provided in each size, and each is avail-



SAE TYPE A, 2-bolt mounting flange standard. Foot mounting (illustrated) optional.

SAVES UP TO 4 HORSEPOWER!

NEW WEBSTER "J" SERIES HYDRAULIC PUMP

HERE'S HOW WEBSTER PUTS NEW EFFICIENCY IN HYDRAULIC POWER . . . .

1 PRESSURE BALANCED WEAR PLATES — for high volumetric efficiency; prevents clearance changes due to heat.

2 NEEDLE BEARINGS — power-saving, anti-friction operation.

3 ONE PIECE GEAR AND BEARING JOURNAL UNITS — assure minimum deflection and proper alignment on both drive and idler assembly.

4 FREE-FLOATING INTERNAL SPLINE DRIVES - no key failures.

5 THRUST BEARING ON DRIVE SHAFT — absorbs compound driving thrusts.

6 DOUBLE LIP SEAL ON DRIVE SHAFT — gives added protection against seal failure and dirt.

Now — hydraulic power for your biggest mobile rig and the toughest jobs you can put it on. Webster's new "J" pump delivers 2000 psi — does it on less fuel and saves up to 4 horsepower in the bargain!

It's the result of a combination of pressure balanced wear plates and anti-friction bearings. Here's top efficiency from all-new Webster design that rates 10% or more above others in competitive ratings. Moreover, you get equally important advanced features (see sectional view) to assure dependable, trouble-free service.

Webster "J" series pump is trim, *very compact* — fits into tight quarters, mounts easily. It's available in 10 sizes from 5 to 40 gpm. Ask your Webster Electric representative for all the facts on this powerful new pump — or write direct for Bulletin HYI-I.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

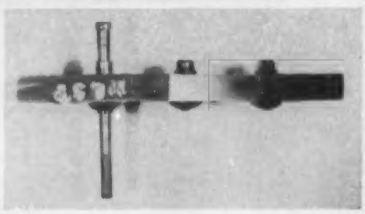
RACINE · WIS

SPHERCO®
BEARINGS

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.

WRITE FOR BULLETIN 257

SPHERCO
A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVE. • AURORA, ILL.
Circle 500 on Page 19



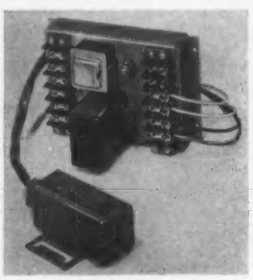
able in a variety of grip lengths. Rivet is a two-piece design consisting of pin and sleeve with integral locking collar. During installation, pin is mechanically locked in place within sleeve by locking collar which is automatically pressed into a conical space between pin and sleeve. **Huck Mfg. Co.**, 2480 Bellevue Ave., Detroit 7, Mich.

Circle 656 on Page 19

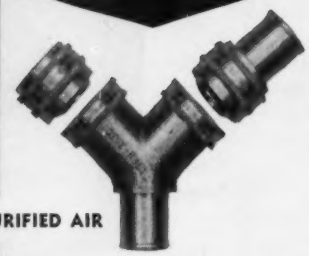
Proximity Switch

can be used under unfavorable conditions

Proximity switch is designed for use as limit, interlock, counter, or indicator sensor under such unfavorable environments as those created by oil, grit, extreme vibration, dirt, or sludge. Switch consists of a sensor and separate transistorized amplifier with plug-in-relay. Sensor detects magnetic material without physical contact and feeds an electrical output to remotely located bistable amplifier. Amplifier operates DPDT relay, which is wired to the circuit in the same manner as a conventional limit switch. Two components of the unit can be located up to 150 ft apart without use of shielded wire. Switch senses products with highly polished surfaces without touching them, and detects small items without retarding their flow. It can be used to sense products ranging from automotive frames to bottle caps. Unit has an adjustable sensitivity range of $\frac{1}{8}$ to $\frac{1}{2}$ in. It operates on 115-v, 60-cycle

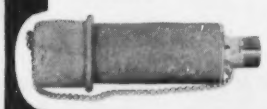


DISCONNECTS
Exploring new Horizons



PURIFIED AIR

Full line flow into "Y" socket. Metering orifices in socket permits supplying required air for one to six outlets.



LIQUID OXYGEN

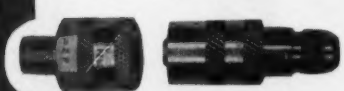
Double shut-off type with modified bayonet locking. Metal to metal seals operating against 75 PSI, minus 310°F. Meets A. F. specs.

MINIATURE COUPLING

Weighing only 1/4 oz. with 7/16" OD and 1-1/8" OAL, this aluminum coupling designed for 1/8" tubing connections to missile motor. Easy Pulomatic ball detent locking action.

COMB. OXYGEN & ELECTRICAL

Connects oxygen and communications wiring to pressurized flying suits, survival kits and capsules. Seal engages and disengages before electrical contacts.



FUEL CHARGING

Straight-thru type with fast Pulomatic ball detent locking. Unique design permits high pressures, light weight construction and flush mounting.

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Circle 501 on Page 19

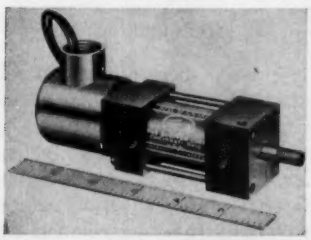
power. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 657 on Page 19

Solenoid-Operated Cylinder

for tooling and automation

CLA Series Valv-N-Hed clamp-type cylinder is a compact, lightweight unit with 1⅛-in. bore. It is for 150-psi air, 250-psi oil, or water. Suitable for tooling and automated circuitry, unit has integral solenoid-operated valve. Unit is furnished from stock in spring-return or double-acting types, in 1, 2, and 3-in. strokes. It is designed for 115-v, 60-cycle, continuous-duty operation at temperatures to 180 F with power consumption rated at 10 W.



Cylinder is supplied standard with grommet-type electrical outlet, or alternately with ½-in. NPT conduit electrical outlet and 24-in. thermoplastic-covered leads. Cylinder is 1½ in. square, with short over-all length. **Sheffer Corp.**, 326 W. Wyoming Ave., Cincinnati 15, Ohio.

Circle 658 on Page 19

Servo Indicators

subminiature units have modular construction

Simplified modular-construction approach toward subminiature servo indicators utilizes standard stock parts and is suitable for prototype and limited-production applications. Indicators shown include several possible configurations. They are available in 2-in. hermetically sealed cases conforming to MS 33639. Basic module is the gear box in which up to seven 0.0937-in. diam shafts are mounted in ABEC-7 ball bearings. Gear ratios of up to 65,000:1 are obtainable using Precision 2 stock gears. Component module utilizes standard plates for mount-

NEW BRUSH GRADES

FOR SMALL LOW-COST MOTORS

(Such as flush commutator types)

BRUSH SPRING DESIGNS

are important too!

Stackpole offers full engineering facilities for designing brush springs for optimum performance.

Note: Stackpole Brushes are sold only to original equipment producers—NOT as replacements.

The increasing use of flush commutators in inexpensive little motors often brings big problems in brush selection. Even though the brushes must be inexpensive too, it is equally essential that they have adequate life, give good commutation and avoid burning or grooving the commutators.

Recent Stackpole fractional horsepower brush developments pave the way to substantial improvement in both brush and overall motor performance on many of these "trouble" jobs.

As a leading small motor brush producer, Stackpole welcomes the opportunity to "Custom Engineer" these grades to the individual requirements of your specific motors. No obligation is involved. You be the judge!

Ask your local Stackpole representative or write to STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE *Custom Engineered* BRUSHES

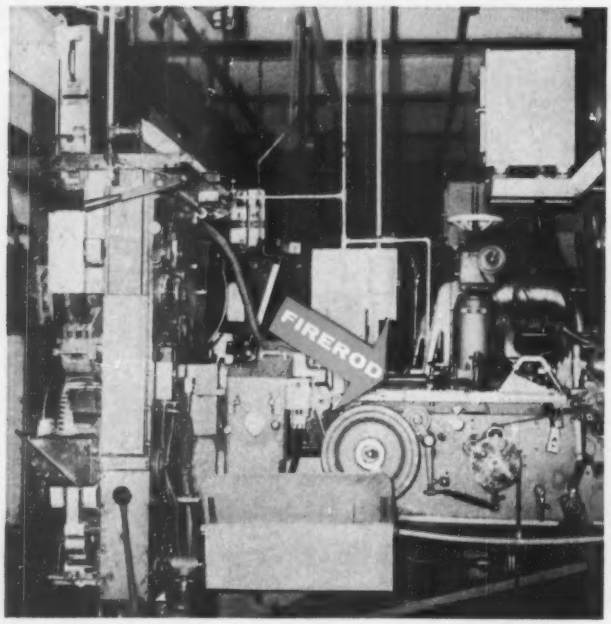
for all rotating electrical equipment

CONTACTS • VOLTAGE REGULATOR DISCS • CATHODIC PROTECTION ANODES • FIXED & VARIABLE RESISTORS • BEARINGS • MOLDS & DIES • FRICTION SEGMENTS • SEAL RINGS CLUTCH RINGS • CHEMICAL ANODES • HEATING ELEMENTS • WELDING CARBONS • POROUS CARBON . . . and dozens of other carbon, graphite and powdered metal products.

Circle 502 on Page 19

DESIGN NEWS

For Heating Unit Applications



BEFORE: **HEATING UNIT LIFE ONLY 60 DAYS!**

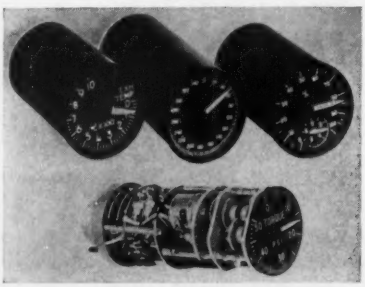
AFTER: ***NOT A SINGLE HEATING UNIT FAILURE IN 3 YEARS... SINCE FIRERODS HAVE BEEN ON JOB!***

Since Brown and Williamson (maker of famous cigarettes) switched to Firerod Cartridge Heaters to dry the adhesive used in sealing cigarette paper, burn-out and down-time have ceased to be a problem. Before, one electrician kept busy replacing burnt out cartridge heaters on their many machines. Down time and replacements cost thousands of dollars per year.

Firerod Cartridge Heaters have established a new concept in heat concentration and heater life. Temperatures up to 1500°F and even higher are possible. With any temperature, Firerods will give you longer heating unit life.

How can **FIRERODS** *help you—*
Write for Firerod Bulletin No. 367.

WATLOW
ELECTRIC MANUFACTURING CO.
1384 Ferguson Avenue
St. Louis 14, Mo.



ing size 8 or size 10 rotating component. Dial section, another module, also utilizes standard parts. Dial configurations are photographically processed to an accuracy of 6 min of arc. **Servo Development Corp.**, 567 Main St., Westbury, N. Y.

Circle 659 on Page 19

Sheet Packing

of Hypalon and asbestos

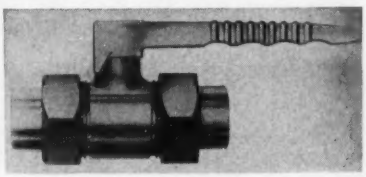
Compressed sheet packing combines outstanding chemical, ozone, and aging resistance of Hypalon synthetic rubber with strength, inertness, and economies of asbestos. Material shows superior resistance to inorganic and organic acids, aromatic hydrocarbons, and general alkalies such as caustics. It is not subject to cold flow under compression, has good flexibility for convenience in installation, and does not become brittle under exposure. Compressibility is approximately 20 per cent, and recovery, a minimum of 40 per cent. Uses include gasketing on flanges, condenser heads, columns, hand and manholes, and pump casings. Material is available in five thicknesses from 1/64 to 1/8 in., in sheets 50 x 50, 50 x 150, and 150 x 150 in. **Keasbey & Mattison Co.**, Ambler, Pa.

Circle 660 on Page 19

Ball Valves

for temperatures from −300 to +400 F

Valves are available for installation in tight or hard-to-get-at spots.



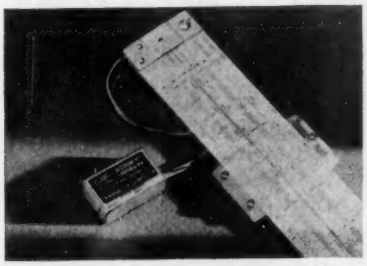
Circle 503 on Page 19

Maintenance requires only standard tools. Units have been tested to 1000 psi in sizes from ¼ to ¾ in. and to 600 psi in 1 to 2-in. sizes in stainless steel. Valves perform in temperatures from −300 to +400 F. Available at present in stainless and carbon steel, they will be furnished also in plastic and brass. Units are suitable for handling light slurries and for throttling for close regulation of flow. Handle is available in colors for service identification. **Cooper Alloy Corp.**, Bloy Street and Ramsey Avenue, Hillside, N. J.

Circle 661 on Page 19

Transistor Amplifier

for servo, audio, and pulse uses



Moderate - temperature, medium-gain voltage amplifier is for severe vibration conditions. It is small in size, and has gain stability over temperatures from −50 to +50 C. Open-loop is over 40 db, and closed-loop gain is 10 to 26 db. Amplifier is enclosed in a stainless-steel case and has a vibration specification of 400 g at 2 kc without microphonic noise. **Taber Instrument Corp.**, Section 168, North Tonawanda, N. Y.

Circle 662 on Page 19

Analog-Digital Converter

with servo-type mounting is miniature unit

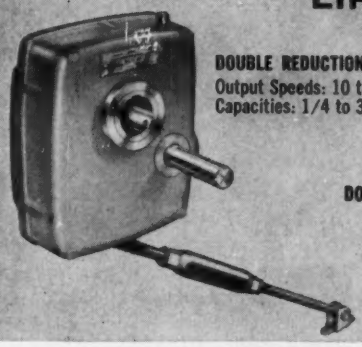
Miniature analog-to digital converter can be integrated directly to size-15 transducers for use in airborne computer applications. Unit is typically used in systems of fire control, navigation, and other automatic-control applications where it is necessary to represent angular shaft rotation by coded digital outputs to computer systems. Type 18-

AVAILABLE FROM LOCAL STOCK

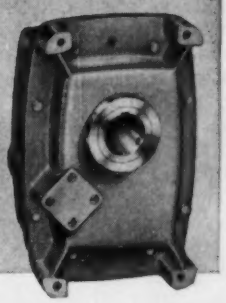
FOOTE BROS. SHAFT MOUNTED DRIVES

WITH Duti-Rated® LIFETIME GEARING*

SINGLE REDUCTION
Output Speeds: 90 to 420 RPM
Capacities: 1/4 to 40 HP



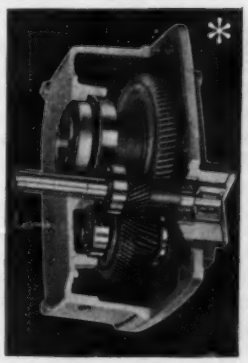
DOUBLE REDUCTION
Output Speeds: 10 to 160 RPM
Capacities: 1/4 to 30 HP



DOUBLE REDUCTION FLANGE MOUNT
Output Speeds: 10 to 135 RPM
Capacities: 1 to 7 HP

Foote Bros. Shaft Mounted Drives offer more efficient, more economical, power transmission. They incorporate exclusive Duti-Rated Lifetime Gearing — the high hardness, balanced design, premium quality gearing that combines greater load carrying capacity with long service life.

Used with standard V-Belts and Sheaves, Foote Bros. Shaft Mounted Drives will provide virtually any output speed you may require. Quick, easy installation on driven shafts with diameters from 15/16" to 3-7/16" saves time, labor . . . eliminates need for reducer mounting, couplings, and adjustable motor mount. Built-in Backstop to prevent reverse rotation, Automatic Overload Release Torque Arm, Variable Pulley, are available as optional equipment.

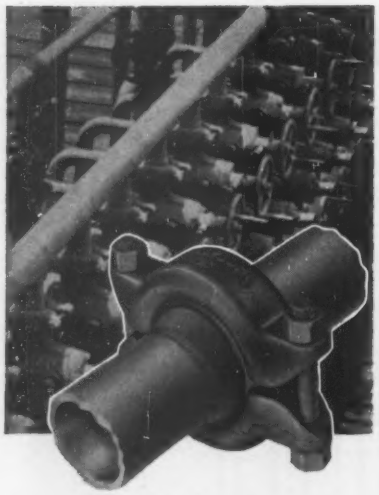


The complete Foote Bros. Shaft Mounted Drive line is made in accordance with all applicable AGMA Standards

Write for NEW SHAFT MOUNTED DRIVE CATALOG

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 South Western Boulevard, Chicago 9, Illinois
POWER TRANSMISSION DRIVES

Circle 504 on Page 19



GRAYLOC

Pipe Connections Make-Up In 3 Minutes

Unlike the 3-minute egg or the 3-minute car wash, GRAYLOC 4-inch Pipe Connections actually can be made up in 3 minutes by an unskilled laborer. What's more, the connection will test up to 10,000 p.s.i. every time. Two men can make-up a 24-inch connection in 15 minutes.

GRAYLOC, with its new principle in pipe make-up, can be broken out and re-made repeatedly with no wear or other damage to the connections and without replacement of the seal ring.

The GRAYLOC principle features flexible tapered lips of the seal which are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect. This design makes it possible for GRAYLOC to withstand full vacuum, high external pressure or extreme internal pressure.

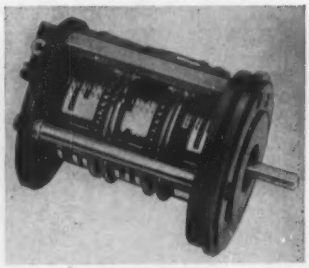
GRAYLOC has practical applications in missile, chemical, petroleum, and atomic energy processes.

For additional information, write, wire or telephone Gray Tool Company.

GRAY Tool Company

P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 5505

Circle 505 on Page 19



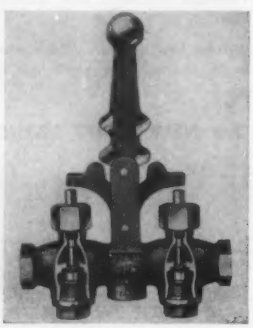
1077 converter measures 1.437 in. diam and is 1 15/16 in. long including ½-in. shaft. Weight is 3.37 oz, including housing and 18-in. wire leads. One hundred revolutions of input shaft are required to complete entire code from 0 to 999 or from −0 to −000. Angular bit length is 18 deg, and accuracy is within ⅓ of a bit at any point in entire range. Maximum rated input speed is 400 rpm. **Courter Products Div., Model Engineering & Mfg. Inc.**, Boyne City, Mich.

Circle 663 on Page 19

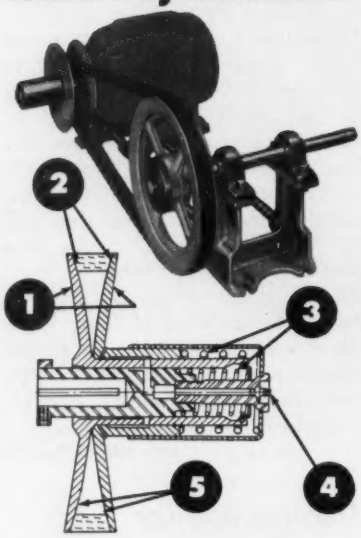
Air-Control Valve

has aluminum body

No. 234-AL valve with aluminum body is used with any air or hydraulically operated machine. When lever of valve is moved to right, operation of machine is forward; when lever is moved to left, operation is rearward. With lever in center position, machine is inoperative. Hold-open feature locks lever in either forward or reverse position. Valve is self-closing and closes automatically when operator releases lever. Features include: spring-loaded poppets to help assure tight shut-off; oversized stems to resist bending and give air-tight sealing between packing and stem; raised seats with in-line disc contact to aid tight shut-off. Discs are Buna-N rubber compound, and



feature by feature...



INDUSTRY'S MOST EFFICIENT VARIABLE SPEED PULLEY

1. Both sides of the driving disk open simultaneously and equally to give constant belt alignment.
2. Power is transmitted through sides of the belt to a grooved sheave to insure maximum efficiency and prevent slippage.
3. Each side of the driving disk is independently actuated by its own spring, eliminating rachets, cogs, gears or other moving parts subject to constant maintenance and wear.
4. Oilite bronze bushings on fractional hp. units provide life-time lubrication.
5. Curved pulley faces maintain full contact with belt sides at all times, greatly increasing overall efficiency.

Pulleys are available in a complete range of sizes, fractional to 15 hp.—full 3 to 1 ratio. Immediate delivery from stock.

Request recommendations for your application. Ask for Catalog P-58.

Lovejoy FIRST NAME IN VARIABLE SPEED PULLEYS

LOVEJOY FLEXIBLE COUPLING CO.

4818 West Lake Street, Chicago 44, Illinois
Telephone: EStebrook 9-3010

Circle 506 on Page 19

lever is cast iron. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 664 on Page 19

Roller Chain

handles heavy loads

Offset side bar roller chain can be used on heavy drives where difficult operating conditions are encountered. Chain provides sure action of ASA roller chain, plus added clearances to resist faulty articulation caused by rust or accumulation of foreign materials. Chain is made up of a series of identical links held together with cotter or riveted pins. If elongation occurs during operation, any link can be removed easily in a short time. Chain compensates for slight misalignment of sprockets without excessive damage. It is available in sizes to fit standard 100 to 180 sprockets in single and double widths. Dept. O, Atlas Chain & Mfg. Co., West Pittston, Pa.

Circle 665 on Page 19

General-Purpose Valve

for use on mobile equipment

V-34 series valve is a general-purpose unit employing the sectional principle, designed for use on lift trucks and other mobile equipment where supplementary operations are frequently added to standard models. Basic valve is composed of a two-plunger, cast-in-block section with integral pilot-operated relief valve. All mounting holes, pump, and tank connections are in basic section. Additional operating sections can be added to valve in field as required without disturbing original piping connections. Hydreco Div., New York Air Brake Co., 9000 E. Michigan, Kalamazoo, Mich.

Circle 666 on Page 19

MicroRold®
STAINLESS STEEL
SHEET & STRIP

FIFTEEN YEARS AGO, we were the first stainless steel sheet producer to recognize the superiority of the Sendzimir Cold Reduction Process over conventional rolling equipment for exceptionally close tolerances.

Our equipment is such that tolerances can be held to as low as 3% (plus or minus), as compared to the A.I.S.I. maximum allowable variation of 10%. This "Thinness Control" means the ability to control decimal thickness with micro-accuracy, giving you more stainless area per ton or the equivalent area with less weight. It is this controlled accuracy and uniformity that directly relates to fabricating economies and satisfaction in the ultimate end use.

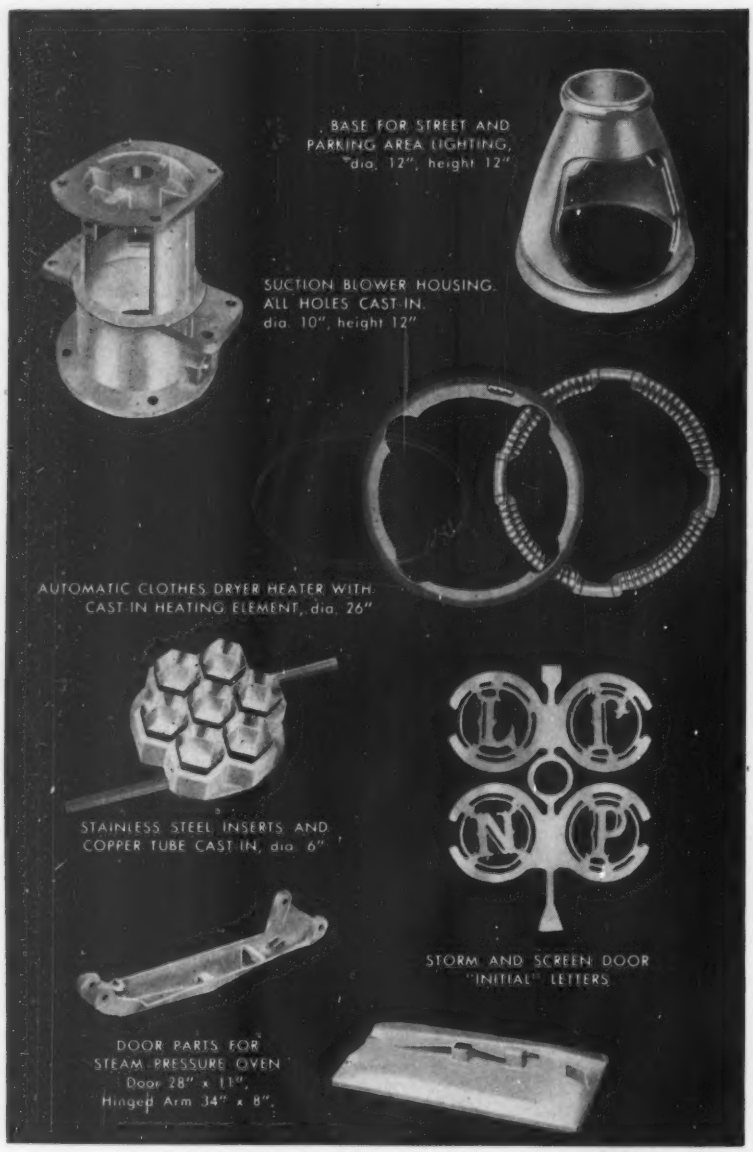
MicroRold Stainless Steel Sheet is available in widths up to 36" in gauges from .005 to .109, and in widths up to 48" from .010 to .109 in all commercial grades, finishes and tempers. MicroRold Strip can be supplied in widths up to 23 15/16" in gauges from .010 to .109, and VERI-THIN Strip as thin as .0015 to .009 in all commercial strip finishes.

Distributed by steel warehouses throughout the world!

Send for your copy of "MicroRold Stainless Steel Handbook"

WASHINGTON STEEL CORPORATION
WOODLAND AVENUE • WASHINGTON, PENNSYLVANIA

Circle 507 on Page 19


BASE FOR STREET AND PARKING AREA LIGHTING, dia. 12", height 12"
SUCTION BLOWER HOUSING, ALL HOLES CAST-IN. dia. 10", height 12"
AUTOMATIC CLOTHES DRYER HEATER WITH CAST-IN HEATING ELEMENT, dia. 26"
STAINLESS STEEL INSERTS AND COPPER TUBE CAST-IN, dia. 6"
STORM AND SCREEN DOOR "INITIAL" LETTERS
DOOR PARTS FOR STEAM PRESSURE OVEN Door 28" x 11", Hinged Arm 34" x 8"

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The method of casting that assures density, homogeneous structure, with surfaces that take a high finish. Illustrated castings indicate how other metals are cast with aluminum to meet specific performances. For more ideas and recommended applications, write for new brochure. Our permanent mold engineers will be happy to work with you.

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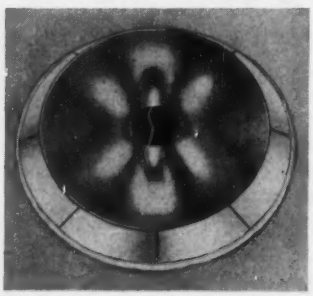
ENGINEERING DEPARTMENT

EQUIPMENT

Strain Compass

provides visual indication of main strain directions

Strainline photoelastic strain compass provides instantaneous visual indication of principal strain and stress directions at desired points on a test surface. It permits complete and accurate strain direction information with a single compass,



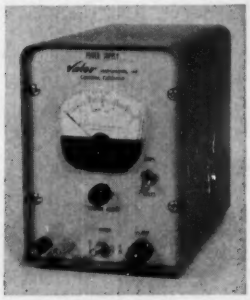
eliminating need for computation and interpretation of multiunit installations. No external instrumentation or connections are required. Built-in polarizers permit compasses to be used and read easily in natural or artificial light; no electrical or mechanical magnifiers are necessary. Compasses indicate principal stress direction of both static and dynamic strains, and in certain cases can be used for stress-ratio determination. Type C-37-10 has effective gage diam of 3/8 in. and Type C-100-10 has 1-in. gage diam. **Electronics and Instrumentation Div., Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.**

Circle 667 on Page 19

Power Supply

transistorized unit has double regulation

Double regulation in Model PS102M power supply provides high regulation and low ripple. Other features of the compact, portable, variable



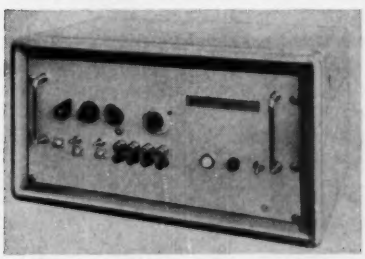
unit, designed specifically for transistor circuit applications, are excellent transient response with a controlled under and over-shoot, high stability, and a floating output. Output is 6 to 30 dc at 0.5 amp; input is 105-125 v, 60-400 cps. Size is 5 x 7 x 8 in. **Valor Instruments Inc.**, 13214 Crenshaw Blvd., Gardena, Calif.

Circle 668 on Page 19

Time-Delay Generator

operates over five ranges from 0.1 to 10,000 mu sec

Time-delay generator provides calibrated time delay, continuously variable, with accuracy of better than ±1 per cent of full range (each range) and linearity tolerance of ±1 per cent. It is operable over five ranges from 0.1 to 10,000 mu sec. Aside from usual delay-line work, unit has applications in computer development. Wide variety of input signals can be accommodated. Unit is triggered by a periodic wave of 15-v peak-to-peak amplitude, or an 8-v peak negative or positive pulse of noncritical shape. Delay is presented as time between two pulses, approximately triangular, and of at least 20 v amplitude. Rise time is less than 0.05 mu sec. **BJ Electronics, Borg-Warner Corp.**, 3300 Newport Blvd., Santa Ana, Calif.



Circle 669 on Page 19

...Better still with new

MF Whiz-Locks®

One-piece free spinners
that won't let go. So simple they'll amaze you.
So original there's a patent pending.

MacLean-Fogg's new Whiz-Lock is a one-piece, free-spinning lock nut that is simplicity itself. Spin it into place, wrench it tight and forget it. The scientifically designed spiral teeth take just the right grip on the work to prevent accidental loosening. Yet it removes readily on application of at least 25% more torque than was used to apply it.

MF Whiz-Locks have been as thoroughly tested as any new fastening device ever offered. Test them yourself soon. Samples are available free. Ask for hex nuts or bolts—with or without flange—in sizes from No. 6 to ⅜". State size desired.

SEND FOR SAMPLES

MAC LEAN-FOGG MF LOCK NUTS

MacLean-Fogg Lock Nut Company
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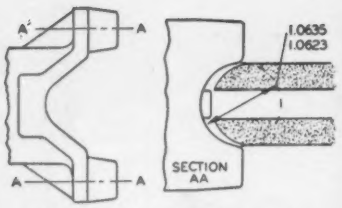
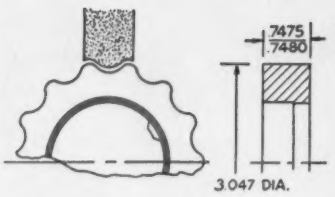
1925 35 1960 ANNIVERSARY

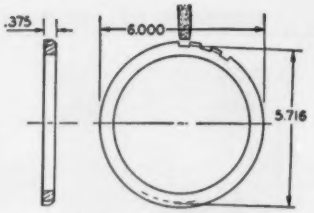
Circle 509 on Page 19



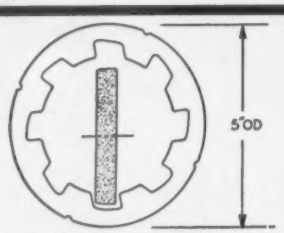
Job: Grind 2 half-rounds from rough
Part: Universal Joint
Output: 400/hr, floor to floor
Material: Pearl. Mall. Iron
Pcs/load: 10



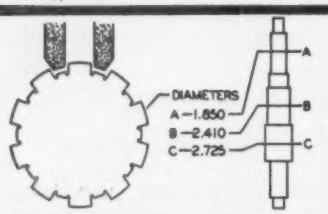
Job: Contour grind 14 lobes
Part: Pump rotor
Output: 88/hr, floor to floor
Material: Steel 200 Brinell
Pcs/load: 12



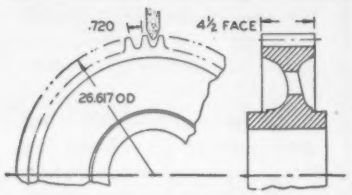
Job: Grind 24 teeth from solid
Part: Splined spacers
Output: 18/hr
Material: Steel
Pcs/load: 9



Job: Contour grind internal cams
Part: Roller clutch cam
Output: 60/hr
Material: Case hardened steel
Pcs/load: 2



Job: Straddle grind 3 sets of 10-splines (parallel sides)
Part: Transmission mainshaft
Output: 2.7/hr/spline set
Material: Steel 61-64 Rc
Pcs/load: 1

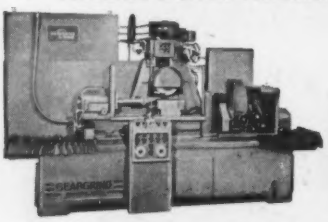


Job: Grind 94 teeth (.017" per side)
Part: Railroad gear
Output: 1.1/hr, floor to floor
Material: Steel 60 Rc
Pcs/load: 1

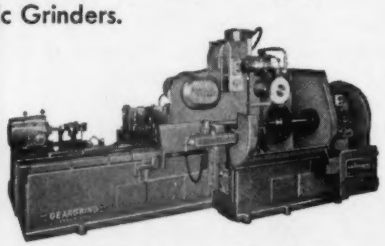
Now You Can Plan on FULLY AUTOMATIC FORM GRINDING

to cut costs, improve accuracy on external and internal contours

Here are some examples. You can do all these jobs—involute, cycloidal, spherical, etc.—at either high production or job-shop rates with top accuracy on highly versatile Detroit Automatic Grinders.

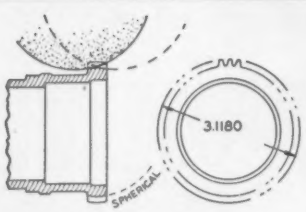


"Detroit" automatic contour grinder for up to 20" PD.

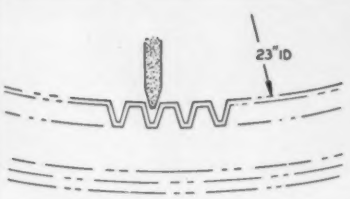


"Detroit" automatic contour grinder for up to 36" external and 30" internal.

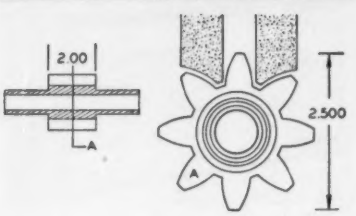
GEAR GRINDING MACHINES DIVISION
MICHIGAN TOOL COMPANY
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN



Job: Spherical grind 48 teeth
Part: Spherical gear coupling
Output: 2.3/hr
Material: Carburized 60 Rc
Pcs/load: 1



Job: Internal grind 157 teeth
Part: Aircraft reduction gear
Output: 1.2/hr
Material: Case hardened
Pcs/load: 1



Job: Straddle grind 8 teeth
Part: After-burner pump gear
Output: 11/hr, floor to floor
Material: Nitrided steel 15N-90
Pcs/load: 1

Circle 510 on Page 19

for longer life

and no oil leakage

specify NARDA Piston Accumulators

FEATURING:

- Self-balancing piston
- Triple "O" ring seal—all three active
- Auto-relieving piston
- End caps provide dashpot action and use same seals as piston, thus requiring only one seal size for spare parts.

FOR:

- Auxiliary power
- Surge dampener
- Emergency power
- Leakage compensator
- Pressure transfer barrier

THREE MOST POPULAR SIZES:

One quart, one-half gallon and one gallon, 13", 18⅛" and 28½" long, respectively. All 4¼" diameter. (Larger sizes: 2½, 5, 10 gallons; all 8⅝" diameter.)

Standard temperature range: —40° to +200° F. Seals also available for fuels and special fluids as well as for temperatures from —65° to 400° F.

For more information about these new Narda Accumulators, as well as other models now in development, write to us at Dept. MD-2.

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Circle 511 on Page 19

THE ENGINEER'S Library

Recent Books

Theory and Application of Mechanical Engineering Measurements. *By Mark B. Moore, professor of mechanical engineering, Rutgers University; 296 pages, 6¼ by 9¼ in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, *$6.75 per copy postpaid.*

This book emphasizes careful analysis and solution of problems rather than rigid adherence to test codes. Philosophy of measurement, and processes and error sources in measurements, are discussed.

Some specific topics covered are pressure, temperature, fluid-flow, and electrical measurements. Special consideration is given to analog computers and radiation measurements.

Theory of Mechanical Vibration. *By Kin N. Tong, professor of mechanical engineering, Syracuse University; 348 pages, 6 by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$9.75 per copy postpaid.*

Modern analytical concepts and techniques are emphasized in treatment of mechanical vibration theory. Topics included are energy methods, differential and integral equations, eigenvalue problem in matrix, and principle of superposition. Important theorems are systematically developed from simple to complex.

Association Publications

Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries. *33 pages, 8½ by 11 in., paperbound, side-stapled; available from Engineering Societies Library, 29 West 39th St., New York 18, N. Y.; $2.00 per copy.*

This list of 155 annotated references was prepared for those concerned with organizing files in engineering offices or libraries. Books,

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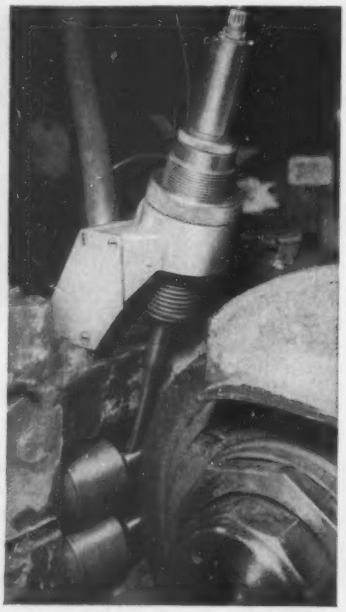
See Sweet's 1960 Prod. Des. File, 7/E

Circle 512 on Page 19



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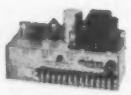
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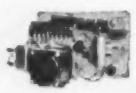
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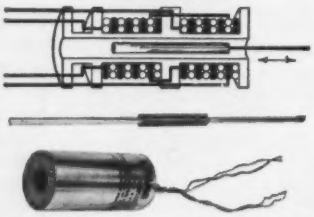

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magazine articles, and pamphlets are listed. References to hand-sorted, punched-card systems suitable for organizing collections of books, notes, abstracts, etc., are included.

EIA Conference on Value Engineering —1959. *165 pages, 6 by 9 in., clothbound; published by Engineering Publishers, P. O. Box 2, Elizabeth, N. J.; available from* MACHINE DESIGN, *$6.00 per copy postpaid.*

Basic concepts and philosophies, techniques, application, and relationship with other work areas are general topics covered by the 19 papers. Some specific topics included are the value engineer and product development, value analysis and its relationship to standardization, and application and use of value engineering techniques.

1958 References on Fatigue, STP 9-J. *76 pages, 8½ by 11 in., paperbound, stapled; available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.;* $3.50 *per copy.*

Listed are 386 references to articles published in 1958 dealing with fatigue of structures and materials. Brief abstracts of many articles have been included, and the listings are arranged so that references may be cut out for filing.

Government Publications

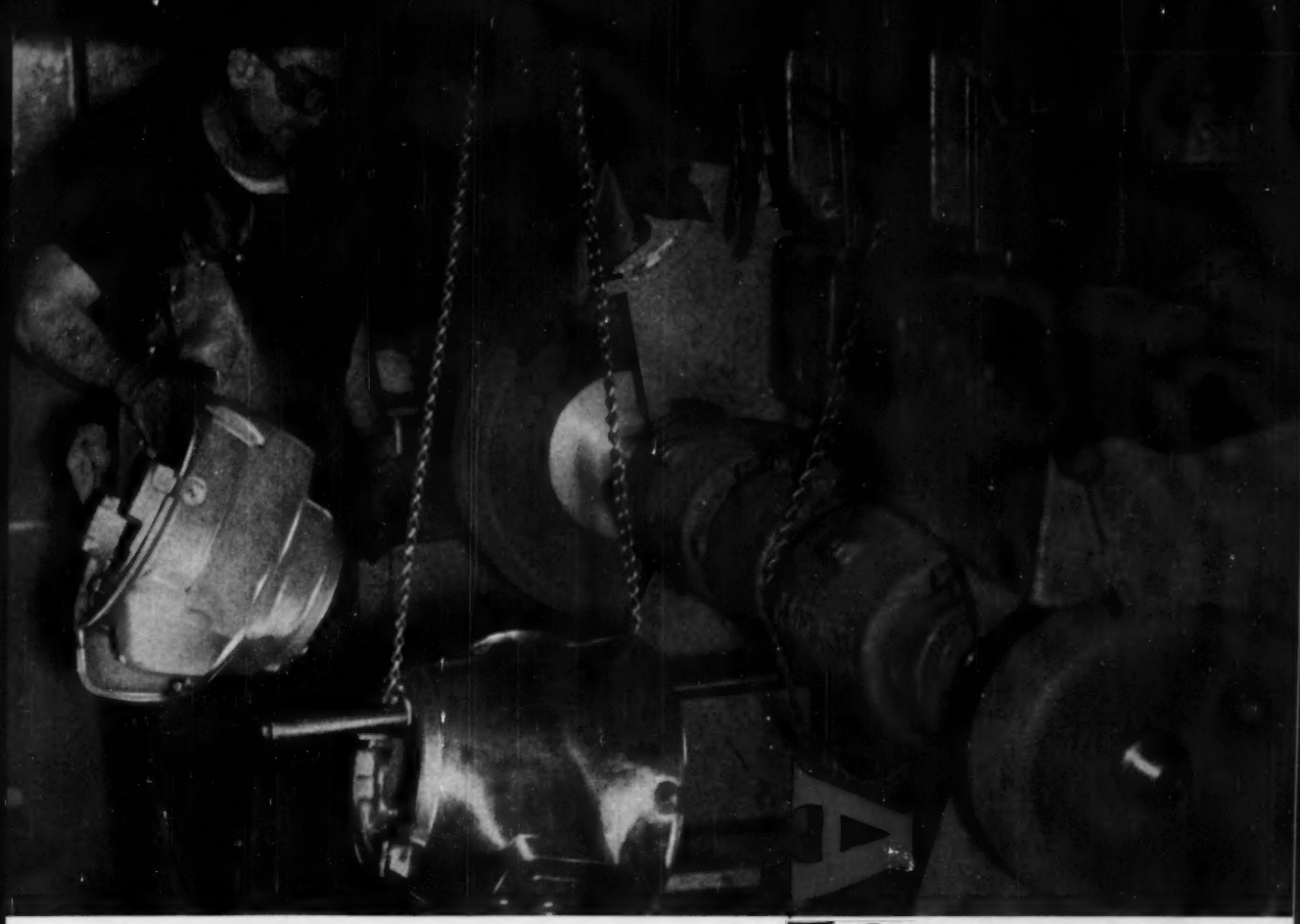
OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151807. Effect of Changing Cyclic Modulus on Bending Fatigue Strength, Part II. By A. A. Blatherwick and B. J. Lazan. University of Minnesota; 34 pages. 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.
Influence of increasing cyclic modulus on stress distribution in bending-fatigue specimens of super-purity aluminum is discussed. Resulting stress redistribution is examined by various types of fatigue tests in common use.

PB 151971. Development of Ultra-High Strength, Temper-Resistant Steels Designed for Improvement of Fatigue Properties through Relief of Residual Stress. By H. B. Nudelman and J. P. Sheehan, Armour Research Foundation; 32 pages. 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.
Molybdenum, chromium, vanadium, and tungsten were utilized as alloying elements to increase temper resistance of steels with carbon contents of 0.30 to 0.55 per cent. Developed were alloys capable of maintaining hardnesses of Rockwell C 40 to 59.

59-21176. Index of Abbreviated and Full Titles of Scientific and Technical Periodical Literature. Source—Publishing House of USSR Academy of Sciences; 237 pages, 8 by 10½ in., paperbound, side-stapled; $4.00 per copy.
This translation of titles of publications of Soviet technical literature is the most complete documentation available. There are 1804 listings arranged alphabetically, by abbreviation.

Circle 513 on Page 19



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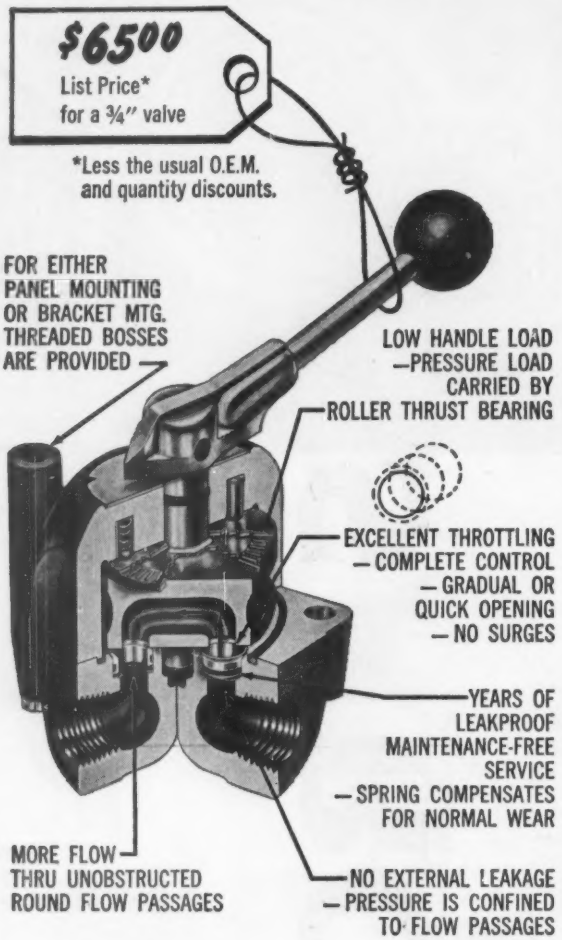

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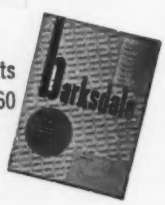

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Patents

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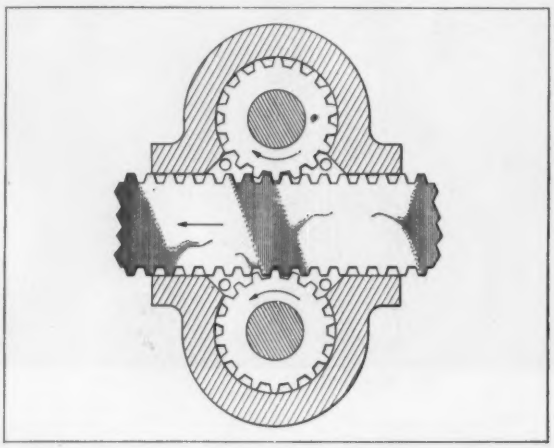
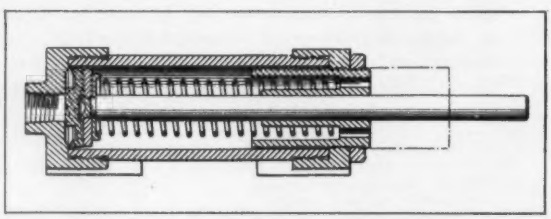


drive the rack in straight-line motion. The volume of fluid under pressure is small and independent of length of stroke. *Patent* 2,919,682 *assigned to Bendix Aviation Corp., Detroit, by Chien-Bor Sung.*

Adjustable-Stroke Cylinder

Stepless adjustment of stroke length in a hydraulic cylinder is accomplished with a telescoping stop assembly. A threaded stop within the outer end of the

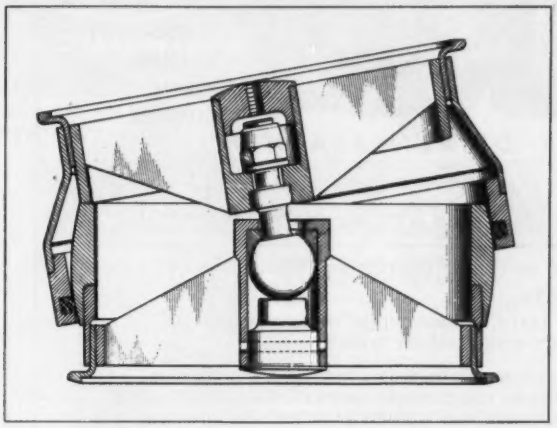


cylinder is adjusted to limit the length of stroke. A locknut holds the stop in any desired position. *Patent* 2,918,040 *assigned to Mead Specialties Co., Chicago, by Mathias L. Lieser.*

Flexible Duct Joint

Both rotative and angular movements are permitted by an articulated joint for tubular ducts. A quad-ring working against a spherical radius maintains a fluid

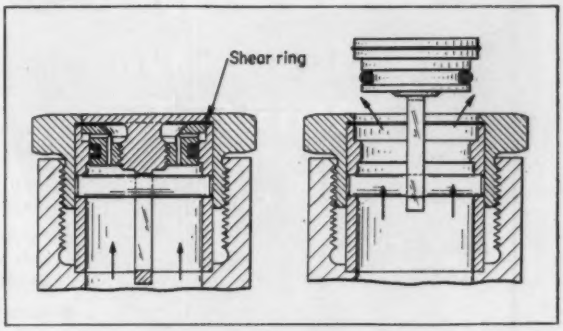
or gas-tight seal during relative motion of the duct elements. An internal supporting structure near the mouth of each tubular element carries a ball-and-socket



type joint. This joint resists the tensile and compressive forces applied to the duct. *Patent 2,921,803 assigned to Southwest Products Co., Duarte, Calif., by Ward D. Tracy and Charles A. Dasney.*

Two-Stage Relief Valve

Insensitivity to momentary pressure surges below a preset value, plus relief of sustained pressures at a low-pressure level are features of a two-stage relief valve. The primary actuating area is directly exposed to both surge and sustained pressures. Restricted passages control pressure access to the secondary area. Pressure drop through the passages reduces the effect of momentary high-pressure surges, but permits normal pressure build-up. When the total force exceeds the restraining force of a shear ring, the piston moves out



of the sleeve, opening the valve to the low-pressure discharge. *Patent 2,920,790 assigned to United Aircraft Corp., East Hartford, Conn., by Raymond N. Quenneville and Earl K. Moore.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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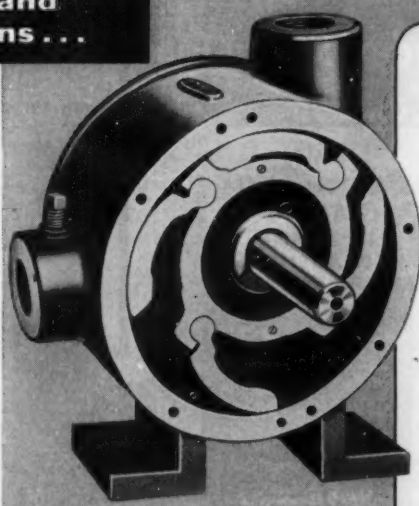

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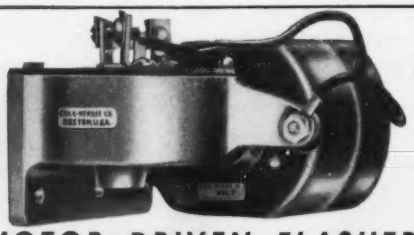

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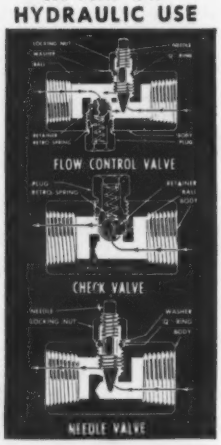

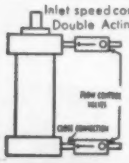

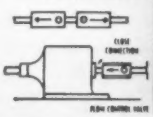

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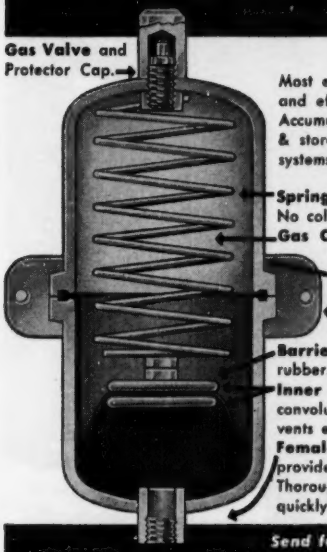

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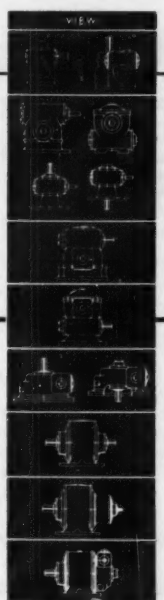

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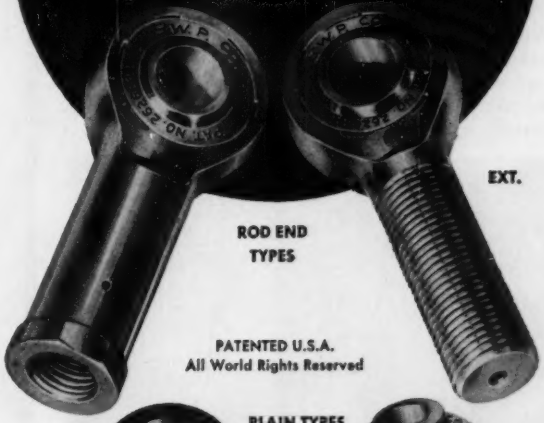

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Cabinets and consoles for electronic and fire control equipment are important elements of ground support equipment in every missile and radar system.

For many years B & P has made cabinets for Nike and other missile systems. These precision cabinets, of magnesium or aluminum, are made as arc-welded assemblies. Special techniques have been developed to prevent distortion during welding. Every cabinet is stress-relieved after welding.

Of the thousands of cabinets and consoles built by B & P, all have been held to close dimensional precision.

When you need lightweight electronic cabinets and consoles, think first of B & P, the most experienced builder of precision light metal electronic ground support equipment cabinets. For more complete details, write to B & P, Detroit.

60-T-10

BROOKS & PERKINS, INC.
1946 W. Fort Street • Detroit 16, Michigan
Offices in Washington and New York

Circle 523 on Page 19

Malleable Casting Redesigned to Stamping Becomes Standard Equipment for Lathe Maker

This malleable cast spanner wrench, used for the handwheel draw-in attachment on a precision bench lathe, involved an elaborate set of patterns, two machining operations plus grinding and finishing. Converting to a die-cut stamping gave improved appearance, reduced weight and better quality. Lots of 100 cost no more than six previously handmade wrenches.

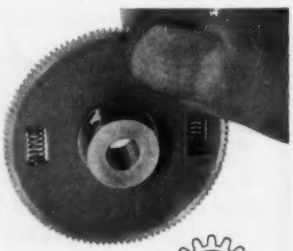
Bulletin F185 explains the highly efficient, specialized, D-R technique of utilizing temporary tooling to produce short-run stampings that cut the work load—and costs—of metal fabricators. Write for it. A print and/or sample, plus quantity, will bring a prompt quotation without obligation.

DAYTON ROGERS
Manufacturing Company

MINNEAPOLIS 7C, MINNESOTA

Circle 524 on Page 19

Now Available!



PRECISION CLASS I & II anti-BACKLASH GEARS
Custom & Stock
to your requirements
1 or 1,000

STOCK . . . Immediate Delivery
CUSTOM . . . Approx. 3 weeks prototype

STOCK SPECIFICATIONS

Precision Class I and II anti-backlash gears: ½" face width, 48, 64, 72, 80, 96 or 120 diametrical pitch, 14½° or 20° pressure angles, diameters from ⅛" to 2". Available in 245T aluminum with solid or clamp type 303 S.S. hubs with choice of 0.125", 0.1875" or 0.250" bores.

CUSTOM AB GEARS TO YOUR SPECS AND DRAWINGS

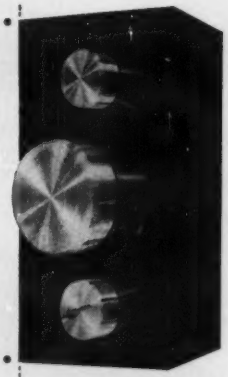
FREE!

Send for supplements to DYNACO E88 Catalog. Shows complete line & specs. on precision stock differentials and new, miniaturized line of precision stock gears.

DYNAMIC
GEAR CO. INC.
AMITYVILLE, NEW YORK

Circle 525 on Page 19

distinctive KNOBS *improve Quality equipment!*



These solid one-piece knobs, accurately hand-crafted from Dural, add a custom touch to fine equipment. Their smart, satin-smooth machined finish and fluted sides harmonize perfectly with ultra-modern product designs.

SPECIAL ENGRAVING AND FINISHES

Also available with colored engraving to meet your specifications or in over-all color anodized finishes.

Write now for complete details and prices.

SPECIFICATIONS

Screw-type mounting for standard 1/4" round or flat shafts. Backs of knobs recessed 3/4" dia. by 5/64" deep for panel mounting. Constructed to withstand hard use...supplied with or without pointer.

KNOB DIAMETERS	KNOB HEIGHTS
3/4"	11/16"
1"	11/16"
1-1/4"	11/16"
1-1/2"	11/16"
2"	11/16"
2-1/2"	11/16"

PACIFIC TRANSDUCER CORP.

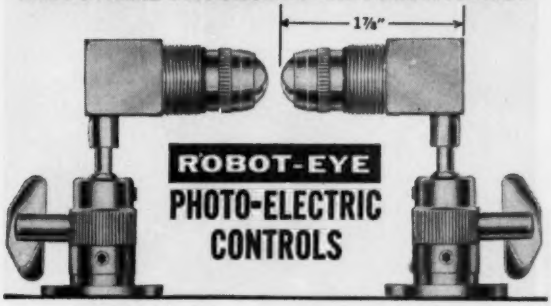
Telephone: GRanite 8-1134 | DEPT. MD-360

11836 WEST PICO BOULEVARD LOS ANGELES 64, CALIF.

Circle 526 on Page 19

count, inspect, control

INDUSTRIAL PROCESSES—AUTOMATICALLY



Transistorized and Tube **AMPLIFIERS**

Plug-in relays, receptacles for plug-in connection of lamps and cells. Additional Plug-in accessories include counters and time delays.

MINIATURIZED

Small, for "tight-spot" installation, yet **rugged** for long service. **Accurate,** for precise automatic control in virtually any industry.

INTER-CONNECTING

Plug-in terminals available for quick connection to any of a wide range of Amplifiers. This design enables you to select the most **economical** amplifier for your job requirements.

INEXPENSIVE

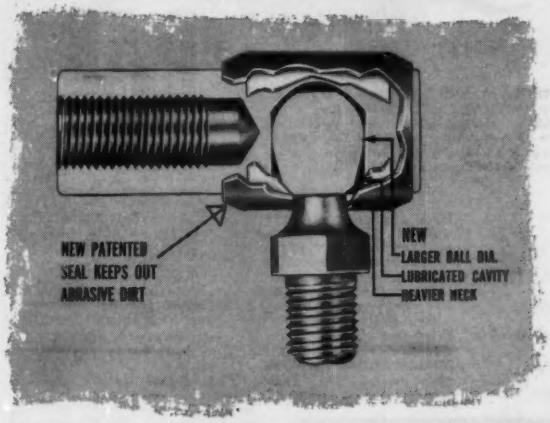
Standard Set P-5 is **$17.** Set P-5S is **$21.** Amplifiers start at **$39.50.** For complete data, write for Brochure MP-3.

standard INSTRUMENT CORPORATION

657 BROADWAY, NEW YORK 12, N.Y.

Circle 527 on Page 19

SHURSEAL PROTECTION GIVES NEW LONG LIFE TO BALL JOINTS BY SUPERIOR



NOW YOU GET EVEN LONGER SERVICE

. . . from Superior "Shurseal" ball joints, particularly under adverse operating conditions. Superior's patented Buna-N "Shurseal" protects the joint from destructive action by any abrasive material which you may encounter. Use them at all exposed locations.

Superior's new simplified ball joint design eliminates unnecessary parts, increases strength, doubles and even quadruples the performance life normally expected from conventional ball joint products.

Initial cost is at least 30% less than old style designs; and end cost factors are even lower due to Superior's greatly extended component life.

Now used in hundreds of automotive, truck, marine, agricultural and other equipment applications, Superior offers for immediate delivery a complete line of ball joints in thread sizes from #10-32 through ¾-16. All are interchangeable with SAE and other published standards.

Complete ball joint assemblies and "packages" can be designed and supplied for special uses.

SEND FOR BROCHURE AND PRICES

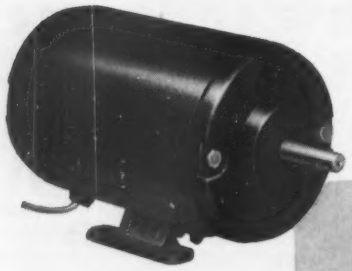
(FREE SAMPLE SENT UPON WRITTEN REQUEST)

SUPERIOR BALL JOINT Corporation

9000 TRIER ROAD • FORT WAYNE, INDIANA

Circle 528 on Page 19

FHP motors... engineered especially for your product



The new RAE M-40 Series, in 3 ratings at 5000 RPM. AC/DC Universal or DC Shunt. M-41 and M-42 rated ½ H.P. M-43 and M-44 rated ¾ H.P. M-45 and M-46 rated 1 H.P. Available with any of Rae's gear units.

RAE motors

RAE engineers are recognized specialists in solving difficult FHP motor applications. By careful analysis and testing of your product, they can save you time and money in selecting the right motor.

RAE offers outstanding service and quality in a large variety of motors. Available in voltages up to 250, and up to 1/2 H.P. (higher for intermittent duty) with many gearhead motor combinations.

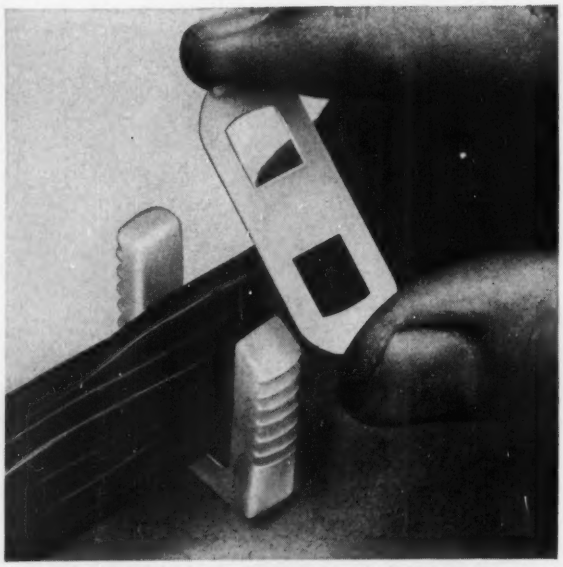
Find out how RAE motors can *improve your product* and *reduce costs* as they are doing for other leading manufacturers.

*Send for the "RAE" Engineering Data Sheet. It will help you supply the data necessary for recommendations and prices.

Rae MOTOR CORP.
2009 Kewaunee Street
Racine, Wisconsin

AC/DC Universal • DC Shunt Wound • DC Series Wound • Gear Reduction Motors • Governor Controlled Motors • Motors for Rheostat Control • Motors for Electronic Control • Permanent Magnet Motors and Gearmotors.

Circle 529 on Page 19



CLAMP WIRE BUNDLES IN SECONDS!

Just place wire bundle inside "U," push keeper down snugly, and this light-weight clamp is securely locked to withstand loadings greater than 50 G's! A Cab-L-Tite* clamp securing 58,000 mils weighs only 0.016 oz.; 8,570,000 mils, 0.832 oz. Proved in aircraft and missiles, Cab-L-Tite* is made of tough DuPont zytel, which meets MIL-P-17091. Removable in seconds for rerouting wires. Write for free literature. *Manufacturer of Bund-L-Tite straps.*

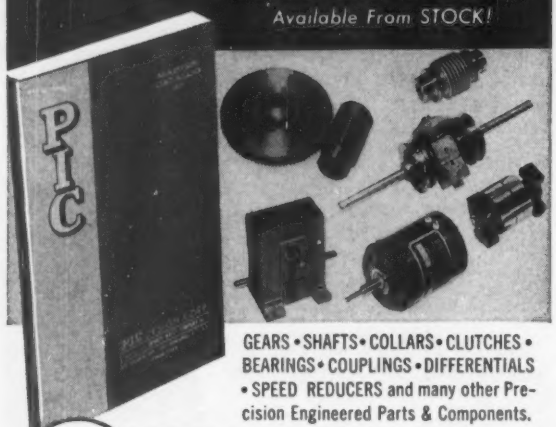
DAKOTA ENGINEERING, INC.
4315 Sepulveda Blvd., Culver City, California *Trade Mark

Circle 530 on Page 19

FREE 416-PAGE PIC MASTER CATALOG #21

Lists over 12,000
PRECISION INSTRUMENT PARTS and ASSOCIATED COMPONENTS
Available From STOCK!

Completely illustrated with detailed drawings, specifications and prices.



GEARS • SHAFTS • COLLARS • CLUTCHES • BEARINGS • COUPLINGS • DIFFERENTIALS • SPEED REDUCERS and many other Precision Engineered Parts & Components.

Send for your FREE copy today.

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Subsidiary of BENRUS WATCH COMPANY, Inc.
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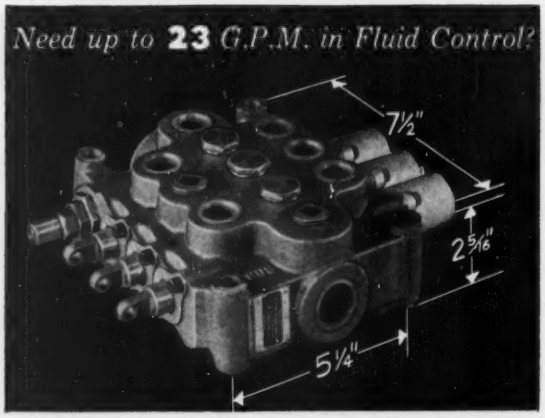

COMPACT HUSCO 3300-SP MULTI-PLUNGER VALVE IS FOR YOU!

One of five basic sizes, HUSCO 3300-SP Valve offers unusual design and performance features that adapt it to wide application. Available to control up to *six* individual cylinders, single or double acting, permitting up to *four* positions of control for extreme versatility. Conventional or parallel circuit, check valve controlled. Compact, precision built for long, trouble-free service. Other HUSCO Multi-Plunger Valves in capacities from 3 to 185 G.P.M.

Write for detailed specifications on HUSCO 3300-SP and complete catalog "Husco's House of Ideas" — or engineering aid on your hydraulic control needs.

HUSCO

HYDRAULIC UNIT SPECIALTIES CO.
PUMPS • VALVES • CYLINDERS
P. O. Box 257-M, Waukesha, Wisconsin
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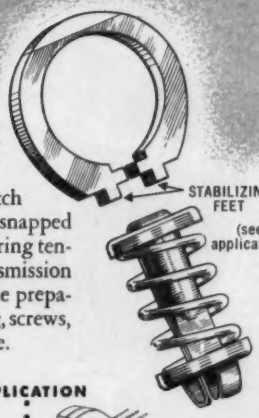
Circle 531 on Page 19

Circle 532 on Page 19

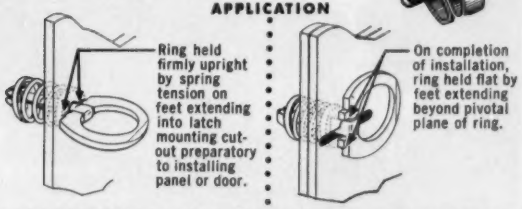
SPRING LOADED LATCH
for removable panels and access doors



Completely assembled, installed in 5 seconds. Latch slips through hole, ring is snapped on. 1/4 turn to operate. Spring tension eliminates noise transmission and vibration. Simple hole preparation. Eliminates riveting, screws, spot welding. Inexpensive.

Write for circular.

APPLICATION


Ring held firmly upright by spring tension on feet extending into latch mounting cut-out preparatory to installing panel or door.
On completion of installation, ring held flat by feet extending beyond pivotal plane of ring.

MAKERS OF POT PRODUCTS

MONADNOCK MILLS
SAN LEANDRO, CALIFORNIA
SUBSIDIARY OF
UNITED-CARR FASTENER CORP., BOSTON, MASS.
OFFICES: ATLANTA, BOSTON, CHICAGO, CLEVELAND, DALLAS, DETROIT, LOS ANGELES, NEW YORK, PHILADELPHIA, SYRACUSE

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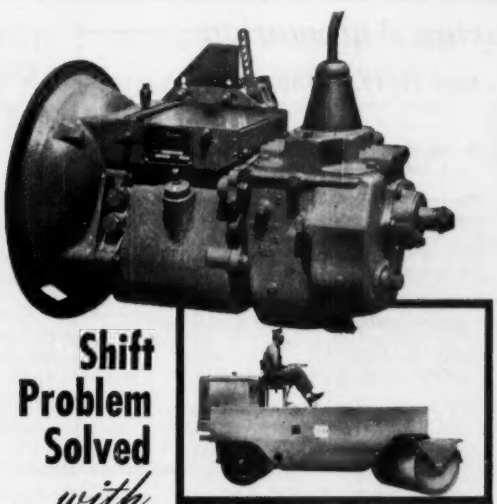

Shift Problem Solved *with* FUNK revers-O-matic®

On this Browning Road Roller, a FUNK Revers-O-Matic® allows the operator to change both speed and direction — *with just one lever*. Hands are left free for other operations. Shifting is smooth and instant, with no wheel spinning.

Another example of how standard FUNK MODULAR POWER UNITS may be combined to handle a *special* job, *without* special engineering costs. Let FUNK help with your power problems.

FUNK MFG. CO. Box 577-F Coffeyville, Kan.

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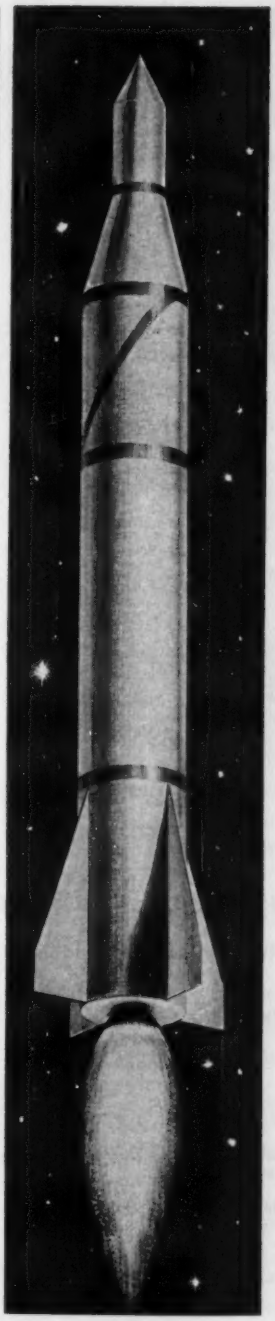

GEAR ACCURACIES IN SECONDS TO GOVERN MILLION MILE FLIGHTS

When Gears of almost unbelievable accuracy are required for America's newest giant missiles designers naturally call upon Equitable Engineering. The nation's leading industries have learned to depend upon Equitable to meet their toughest problems wherever the finest, most exquisite perfection is called for in gears.

- Gears rolling together within 50 millionths of an inch total composite error, as determined by electronic checking equipment.
- Design and production of complete, high precision gear trains guaranteeing input to output accuracies *in seconds*.
- Gear and splined parts from 2 to 200 diametral pitch.

Member: American Gear Manufacturers' Association

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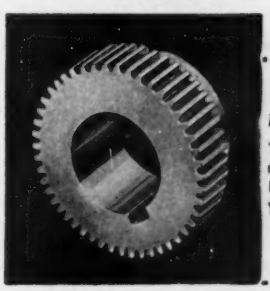

ALL ABOUT EQUITABLE

This fact-filled 16-page catalog describing Equitable's abilities is yours for the asking.

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MAYLINE

PLAN FILE WITH HINGED COVER

Your Choice of Table Combinations!

You can choose your drafting table combinations when you buy Mayline. Notice how the Mayline 5-Drawer plan file is used with the May-O-Matic table. All May-O-Matic combinations shown in folder S-22. Plan file folder is S-20. Send for both today.

Your local dealer can help you in planning the table combination best suited to your needs. See him today!

Mayline Co., Inc.

601 No. Commerce St.

Sheboygan, Wisconsin

MAY-O-MATIC "E" COMBINATION

MAYLINE

MAYLINE

MAYLINE

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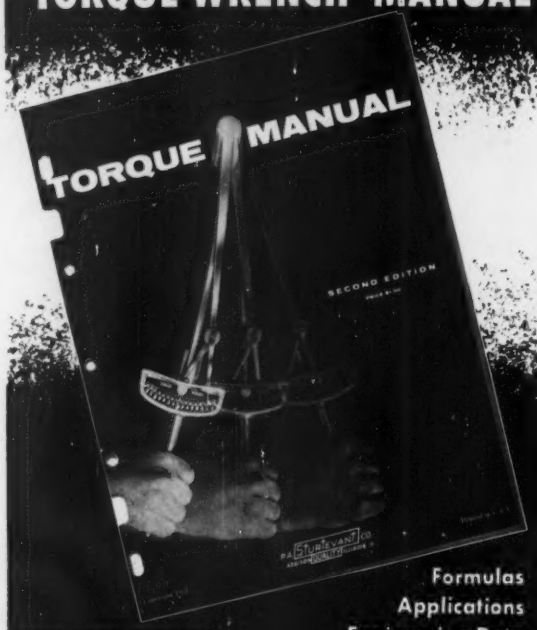
"TORQUE WRENCH" MANUAL



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Formulas
Applications
Engineering Data
Screw Torque Data
Adapter Problems
General Principles

PA STURTEVANT CO
ADDISON QUALITY ILLINOIS

Manufacturers of over 85% of the torque wrenches used in industry

Circle 537 on Page 19

Fourth Conference on Manufacturing Automation

TO BE HELD AT **Purdue University, Lafayette, Indiana . . . April 11, 12, and 13, 1960**

CONFERENCE TOPICS AND SPEAKERS

Engineering Costs—Who Pays? (Automation Panel)

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T. R. BUNNELL, Sylvania Electric Products Inc.

Getting a Grip on Costs and Payoff
K. H. MEYER, Reliance Electric & Engineering Co.

Organizing to Reduce Costs Through Automation
C. D. EVANS, International Harvester Co.

Process Analysis and Machine Procurement
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Automating Assembly
C. H. STANDISH, Designers for Industry Inc.

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Techniques for Parts Handling
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Mechanization for Distribution
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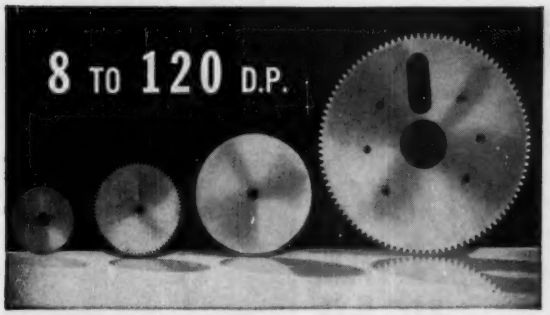
For additional information contact K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind., or AUTOMATION, Penton Bldg., Cleveland 13, Ohio.



LONG LIST OF STOCK GEAR DIES OFFERS YOU BIG SAVINGS!

ACCURATE STAMPED GEARS by *WINZELER* are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of *stock* Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and *economy!* Send blue prints. Tell us about your needs today. No obligation.

SEND FOR...

New list of WINZELER-made stock Gear Dies. Ask for it on company letterhead, *please!*

WINZELER Stamped Gears

WINZELER MANUFACTURING & TOOL CO.
7355 W. WILSON AVENUE • CHICAGO 31, ILLINOIS

Circle 538 on Page 19

HIGH TORQUE — SMALL SIZE

Stearns MODEL "GS" electro-magnetic disc

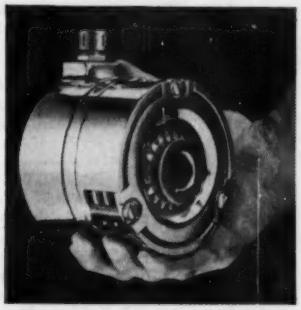
CLUTCH

Sets new standards of reliability and maintenance convenience.

TORQUE RANGE —
Dry—12 to 1260 lb ft
Wet (oil)—
16 to 1140 lb ft

SIZE RANGE —
Diameter—4½ to 9¼ inches
Length—3½ to 6 inches

WEIGHT—11 to 79 lb



New, High Torque, Stearns Model GS Clutches — Save on Space . . . Save on installation . . . Save on maintenance . . . Save on machine downtime . . . Save on faster, smoother, more efficient machine operation . . . Save on longer life — low-cost "wear" elements can be replaced "quick-as-a-wink" with just a screw driver as your complete tool kit.

Start Saving Right Now by calling your local Stearns representative. Or write, stating your specific requirements, directly to Stearns.

For Superior Performance . . . Specify Stearns!

Request Bulletin 226-F

Stearns ELECTRIC CORPORATION
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MILWAUKEE 2, WISCONSIN
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Circle 539 on Page 19

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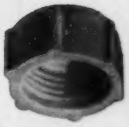
this is

IMPACT STRENGTH



THIS IS PROTECTION!

S.S.White PLASTIC PLUGS AND CAPS

A 12-foot drop to a concrete floor . . . and both the threaded part and its S.S. White cap came through undamaged! All the impact absorbed *on the rim* of this tough acetate cap! Your customers will appreciate the sure protection of S.S. White plastic plugs and caps. They'll also like their easy, non-shredding removal. And *you* will like their quick installation and low cost – only pennies!

Two lines to choose from:

The quality line – of rigid acetate . . . tough, non-brittle, impervious to petroleum-base oils and greases, outstanding impact strength.

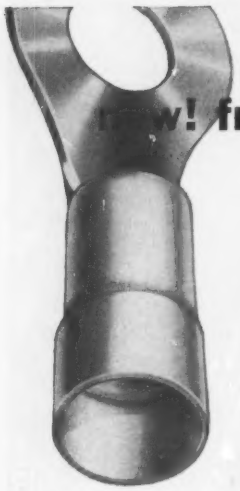
The economy line – of elasto-plastic vinylite . . . a "non-slip grip" for rapid installation and removal, a "stay-put fit."

1052

WRITE FOR FREE BULLETIN *(P5708)*
and samples (please state size and type)

S.S.White **PLASTICS DIVISION**
Dept. 4P, 10 East 40th Street, New York 16, New York
Western Office: 1839 West Pico Blvd., Los Angeles, Calif.

Circle 540 on Page 19



new! from ETC

VIBRAKRIMP*

SOLDERLESS TERMINALS

WHERE HIGH VIBRATION IS A PROBLEM

Even greater strength is added to the basic ETC barrel by a permanently attached sleeve of seamless, annealed, tin-plated brass. Crimped in the same operation as the barrel, the "skirt" part of the sleeve extends beyond the barrel to permanently hold the wire insulation, preventing creep. Wire flexing takes place beyond the terminal, eliminating the vibration hazard. VIBRAKRIMP* terminals are available in all tongue types. Write for samples, prices.

FAST FOOLPROOF POSITIVE CONNECTIONS

*Trade Mark

ETC INCORPORATED
990 East 67th Street, Cleveland 3, Ohio

Circle 541 on Page 19

There's a *New* DIAL HEAD AGASTAT®

for every time/delay/relay application

Here's what you get with every Agastat time/delay/relay

- **Easy adjustment**
- **Repeatable accuracy**
- **Instantaneous recycling**
- **Unaffected by voltage variations**
- **Low power consumption**

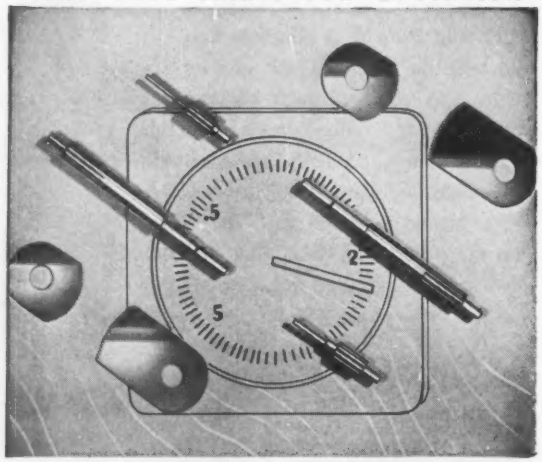
GET THE WHOLE STORY—write today for Bulletin No. SR-10 and find out how Agastat can help you to solve your time delay problems. Write to Dept. **A35-328.**

AGA DIVISION — ELASTIC STOP NUT CORPORATION OF AMERICA
1027 Newark Avenue, Elizabeth, N. J.
Gasaccumulator Co., (Canada) Ltd., 12 Gower Street, Toronto 16, Ontario

Circle 542 on Page 19

20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



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STRAIGHT BEVELS • LEAD SCREWS • RATCHETS
CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

THE *Finest* IN GEARS

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AVAILABLE: Long-established manufacturer of steam and machinery specialties has opening for Mechanical Engineer, preferably with experience in the use of steam for process and heating, as related to the manufacture and application of steam traps, control valves and similar products. To assist Chief Engineer in design, application and sales engineering. Location Eastern Pennsylvania. Send resume of qualifications, experience, when available and salary requirements to Box 964, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: DIESEL PROJECT ENGINEER. Design and/or Laboratory experience in fuel injection, or diesel engineering field capable of independent design and project engineering work on diesel fuel injection equipment. High speed engine experience desired. Immediate opening for qualified applicant. Mutually satisfactory arrangements will be made for personal interview. Write letter of application giving full particulars to: Scintilla Division, BENDIX AVIATION CORPORATION, Sidney, New York.

WANTED: CHIEF ENGINEER. DESIGN ENGINEER. Leading, thirty seven year old, medium size Construction Equipment manufacturer is seeking a Chief Engineer and a Designer. Permanent positions. Excellent remuneration. Generous profit sharing. Many other benefits offered by this highly successful, financially strong Northern Ohio Area Company. Must be thoroughly competent mechanical engineers, both by experience and training, — in Shovel, Crane, Material Handling, Construction, Road Equipment, or similar field. Candidate must demonstrate his competence. Replies treated in strictest confidence. Our personnel are familiar with this ad. Reply in detail, with small photo, directly to Box 966, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio. Employment agencies please do not answer.

Circle 543 on Page 19

Advertising Index

Abart Gear and Machine Co. 189
Acheson Colloids Co., A Division of Acheson Industries, Inc. 35
Acheson Industries, Inc., Acheson Colloids Co. Division 35
A'G'A Division, Elastic Stop Nut Corporation of America 196
Allegheny Ludlum Steel Corporation 87
American Brass Co., The 5
American Machine and Metals, Inc., United States Gauge Division 64
American Smelting and Refining Co., Federated Metals Division 185
Atlas Precision Products Co., Division Prudential Industries, Inc. 151
Automatic Timing & Controls, Inc. 184
Automatic Switch Co. ..... Inside Front Cover
Automotive Gear Division, Eaton Manufacturing Co. 16
Auto-Ponents, Inc. 188

Baldor Electric Co. 167
Barber-Colman Co. 30, 31
Barco Manufacturing Co. 166
Barksdale Valves, Control Division 186
Beaver Gear Works Inc. 196
Bellows Co., The, Division of International Basic Economy Corporation 76
Bethlehem Steel Co. 165
Brooks & Perkins, Inc. 190
Browning Manufacturing Co. 164
Bruning, Charles, Co., Inc., Paragon Revolute Division 42, 43

Carter Controls, Inc. 27
Chart-Pak, Inc. 156
Clare, C. P., & Co. 52, 53
Cole-Hersee Co. 188
Con-Vel Division, Dana Corporation 159
Crane Packing Co. 41
Cutler-Hammer Inc. ..... Back Cover

Dahl, George W., Co., Inc. 39
Dakota Engineering, Inc. 192
Dana Corporation, Con-Vel Division 159
Dayton Rogers Manufacturing Co. 190
Dietzgen, Eugene, Co. 33
Dodge Steel Co. 94
Dynamic Gear Co., Inc. 190

Eastman Chemical Products, Inc., Chemicals Division 183
Eaton Manufacturing Co., Automotive Gear Division 16
Eaton Manufacturing Co., Farval Division ..... Inside Back Cover
Eaton Manufacturing Co., Foundry Division .. 71
Elastic Stop Nut Corporation of America, A'G'A Division 196
Elco Tool and Screw Corporation 81
Electro-Flex Heat, Inc. 160
Equitable Engineering Co. 193
ETC, Inc. 196
Exalco Manufacturing Co. 180

Farval Division, Eaton Manufacturing Co. ..... Inside Back Cover
Federated Metals Division, American Smelting and Refining Co. 185
Fenwal, Inc. 70
Foote Bros. Gear and Machine Corporation .. 177
Formica Corporation 82
Foundry Division, Eaton Manufacturing Co. 71
Funk Mfg. Co. 193

Gabriel Co., The, Valve Division 50
Galland-Henning Nopak Division 46
Garlock Packing Co., The, Plastics Division 67
Gates Rubber Co., The 95
Gear Grinding Division, Michigan Tool Co. 182
General Industries Co., The 163
General Motors Corporation, New Departure Division 11
Goodrich, B. F., Co., The, Aviation Products Division 66
Goodyear Tire & Rubber Co., The, Industrial Products Division 2
Gray Iron Founders' Society, Inc. 169
Gray Tool Co. 178
Gries Reproducer Corporation 47

Hamilton, Alexander, Institute 9
Hamilton Foundry, Inc. 162
Hamilton Watch Co., Precision Metals Division 154
Hanna Engineering Works 92
Hannifin Co., A Division of Parker-Hannifin Corporation 79
Heinze Electric Co. 170
Heli-Coil Corporation 172
Hitchiner Manufacturing Co., Inc. 152
Holo-Krome Screw Corporation, The 75
Hydraulic Unit Specialties Co. 192

Illinois Tool Works, Licon Division 77
Illinois Tool Works, Spiroid Division 65
International Basic Economy Corporation, The Bellows Co. Division 76
International Harvester Co. 45

Jeffrey Manufacturing Co., The 86
Jervis Corporation 54
Joy Manufacturing Co. 59

Kennametal, Inc. 199

Lamb Electric Co., The 90
Leiman Bros. Inc. 187
Licon, Division of Illinois Tool Works 77
Lovejoy Flexible Coupling Co. 178

McGill Manufacturing Co., Inc., Bearing Division 72, 73
McQuay-Norris Manufacturing Co., Electric Products Division 161

MacLean-Fogg Lock Nut Co. 181
Martin-Rockwell Corporation 88
Mayline Co., Inc. 194
M-D Blowers, Inc. 34
Michigan Tool Co., Gear Grinding Division .. 182
Midland Industrial Finishes Co. 156
Mobay Chemical Co. 56, 57
Monadnock Mills 193
Moore, George W., Inc. 188

Norda Hydraulics Corporation, The 183
New Departure, Division of General Motors Corporation 11
New Hampshire Ball Bearings, Inc. 80
Norgren, C. A., Co. 63
Northern Ordnance, Inc. 150

Oilgear Co., The 7
Ortman-Miller Machine Co. 152

Pacific Transducer Corporation 191
Paragon Revolute, Division of Charles Bruning Co., Inc. 42, 43
Parker Fittings and Hose Division, Parker-Hannifin Corporation 79

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BPA NBP

backtalk——

—One More for the Roster

For the second time within a few months, we are printing a picture of Jesse W. Huckert. On the front page of our Engineering News section for December 24, 1959, he was shown

helping to bestow a new ASME award; here he is introduced as MACHINE DESIGN's newest associate editor.

Jesse has been an active member of ASME since 1929 and is currently chairman of the Machine Design Div. He also maintains membership in the American Society for Engineering Education.

Dividing his career between industry and education, he logged 17 years teaching at the universities of South Dakota, Louisville, Maryland, and Ohio State. At OSU he was in charge of setting up courses in kinematics and engineering ethics. Further contributions to education are a textbook, *Analytical Kinematics of Plane Motion Mechanisms*, which he wrote, and the *ASME Handbook, Engineering Tables* volume, which he edited. He holds bachelor's degrees in mechanical and electrical engineering, as well as a master's degree and a Ph.D.

Prior to joining MACHINE DESIGN, Jesse was chief engineer of Carpenter Body Works, Mitchell, Ind.

—Honorable No. 1 Spaceman

American scientists and engineers aim to launch our first astronaut in 1961; prophets of a San Francisco Chinese temple recently said that man will make experimental trips into space during the Year of the Mouse, which began January 28. This year, 4658, is the first of 12 related years in the Chinese lunar calendar system; traditionally, the first year of such a cycle witnesses a break with the past. Since the Chinese year will run into January of 1961, the U. S. space program may provide the break.

Incidentally, the Oriental elders also warned against attempting trips to the moon until the Year of the Hare, or 1963.

—Tellyawhatl'mgonnado!

The growing complexity of life in this age of the obedient atom and the energetic electron quickly outdates even a fairly sound technical education. Science fiction—now accorded the respect formerly reserved for prophets—can easily be confused with *fictional science.*

We're not quite sure which category best fits a mail piece received by one of our editors from a modern "patent" medicine man. The message offers an ELECTRONIC SUPERCHARGER (granted two U. S. patents) to "convert electronic waste into powerhouse performance" in the family car. A modified distributor rotor, it "smashes the atoms in ordinary gasoline and converts them to a new superfuel."

Challenging all I'm-from-Missouri-ists, the patter compares "ordinary" and "electronic supercharged" systems:

> Ordinary ignition sends a mixture of hot electricity (amperage) and cold electricity (voltage) only to **one cylinder at a time.** Only the hot electricity (amperage) is used to explode the gas-air mixture. **The power from the cold electricity (voltage) is completely wasted.**
>
> Electronic supercharging sends hot electricity (amperage) to one cylinder at a time. **BUT** it simultaneously sends **the power** from the cold electricity (voltage) to every other cylinder. This **SUPERCHARGES** the gas-air mixture. This **extra power** added to the gas, in every cylinder, **gives you extra power** every time that mixture is exploded in the cylinder.

All for $9.95—with a dollar-a-minute guarantee for the two minutes required for installation.

Well, as we said at the beginning . . . even a technical education is soon outdated these days. But we're still from Missouri.

Advertising Index

Parker-Hannifin Corporation, Hannifin Co. Division 79
Perfecting Service Co. 174
PIC Design Corporation 192
Porter, H. K., Co., Inc., Riverside-Alloy Metal Division 40
Post, Frederick, Co. 15
Precision Metals Division, Hamilton Watch Co. 154
Prudential Industries, Inc., Atlas Precision Products Co. Division 151

Rae Motor Corporation 192
Reliance Electric and Engineering Co. 28
Revere Copper and Brass, Inc. 37, 38
Riverside-Alloy Metal Division, H. K. Porter Co., Inc. 40
Robbins & Myers, Inc. 84
Rockwell-Standard Corporation, Transmission and Axle Division 74
Rollway Bearing Co., Inc. 78
Ross Operating Valve Co. 1
Russell, Burdsall, & Ward Bolt and Nut Co. 83

Schatz Manufacturing Co., The 61
Sigma Instruments, Inc. 155
Simmons Fastener Corporation 60
Smith, A. O., Corporation 68, 69, 150
South Chester Corporation, Southco Division .. 157
Southco Division, South Chester Corporation 157
Southwest Products Co. 189
Special Products Co. 189
Spherco, Sealmaster Bearing Division, Stephens-Adamson Mfg. Co. 174
Spiroid Division of Illinois Tool Works 65
Square D Co. 48, 49
Stackpole Carbon Co. 175
Standard Instrument Corporation 191
Standard Pressed Steel Co., Industrial Fastener Division 62
Standard Screw Co. 91
Stearns Electric Corporation 195
Stephens-Adamson Mfg. Co., Spherco, Sealmaster Bearing Division 174
Sturtevant, P. A., Co. 194
Superior Ball Joint Corporation 191
Synthane Corporation 200

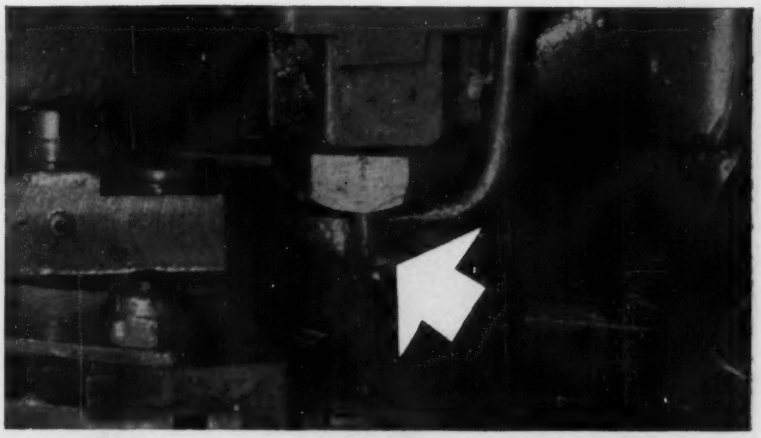
Thomson Industries, Inc. 171
Timken Roller Bearing Co., The, Steel and Tube Division 21
Tinnerman Products, Inc. 96
Torrington Co., The 13
Transmission and Axle Division, Rockwell-Standard Corporation 74
Trent Tube Co. 89
Tube Reducing Corporation 55
Tuthill Pump Co. 85

Uniform Tubes, Inc. 44
Union Carbide Corporation, Union Carbide Plastics Co. Division 93
Union Carbide Plastics Co., Division of Union Carbide Corporation 93
United States Gauge, Division of American Machine and Metals, Inc. 64
U. S. Rubber, Mechanical Goods Division ... 51

Viking Pump Co. 170

Washington Steel Corporation 179
Watlow Electric Manufacturing Co. 176
Webster Electric, Oil Hydraulics Division 173
White, S. S., Plastics Division 195
Winsmith, Inc. 168
Winzeler Manufacturing & Tool Co. 195

Engineers Available or Wanted 196



Machines equipped with the new Kennametal hard carbide nozzles spray sealing material on can lids—at 90% saving in nozzle cost.

KENNAMETAL* Carbide Nozzles outlast stainless steel nozzles by 18 to 1

When a manufacturer of cans replaced stainless steel nozzles with Kennametal tungsten carbide nozzles in machines applying a sealing compound to the metal can lids, they gained these substantial advantages:

ONE — Kennametal carbide nozzles ran 5,328 hours with no apparent wear or change in the size of the orifice. Stainless steel nozzles on the same application lasted an average of only 296 hours.

TWO — Initial cost of Kennametal carbide nozzles was more than double the cost of stainless steel nozzles. But nozzle cost was reduced 90 per cent—because the Kennametal nozzles had an 18 to 1 longer life than the stainless steel nozzles.

THREE — Kennametal carbide nozzles permitted a pressure increase from 55 to 105 psi—which resulted in more uniform coverage, improved quality and fewer rejects of cans due to sealing.

There is a good chance that Kennametal hard carbide compositions can help you solve a problem which involves corrosion, abrasion, erosion or contamination. Our group of hard carbides includes grades that last up to 60 times as long as steel—grades that are three times as rigid as steel—and grades that retain normal properties under prolonged exposures up to 2200°F (at even higher temperatures for shorter periods) and at sub-zero temperatures.

We would like you to know more about Kennametal and how it has helped others solve problems that may be similar to yours. Write to Kennametal Inc., Dept. MD, Latrobe, Pennsylvania. Ask for Booklet B-111-A, "Properties of Kennametal."

*Trademark 97263

Kennametal nozzles are designed in a broad range of shapes and sizes for varying applications.

INDUSTRY AND KENNAMETAL

...Partners in Progress

Why worry about fabricating laminated plastics? That's our job.

There is not much point to fabricating laminated plastics in your own shop. And there are good reasons why. One is the material itself.

Synthane laminates are available in sheets, rods, and tubes, and in over 33 standard grades. Choice of form and grade for your part is important. For example, a part which is basically tubular may have to be cut from a sheet rather than a tube. Or the material itself may have to be modified in order to meet your requirements.

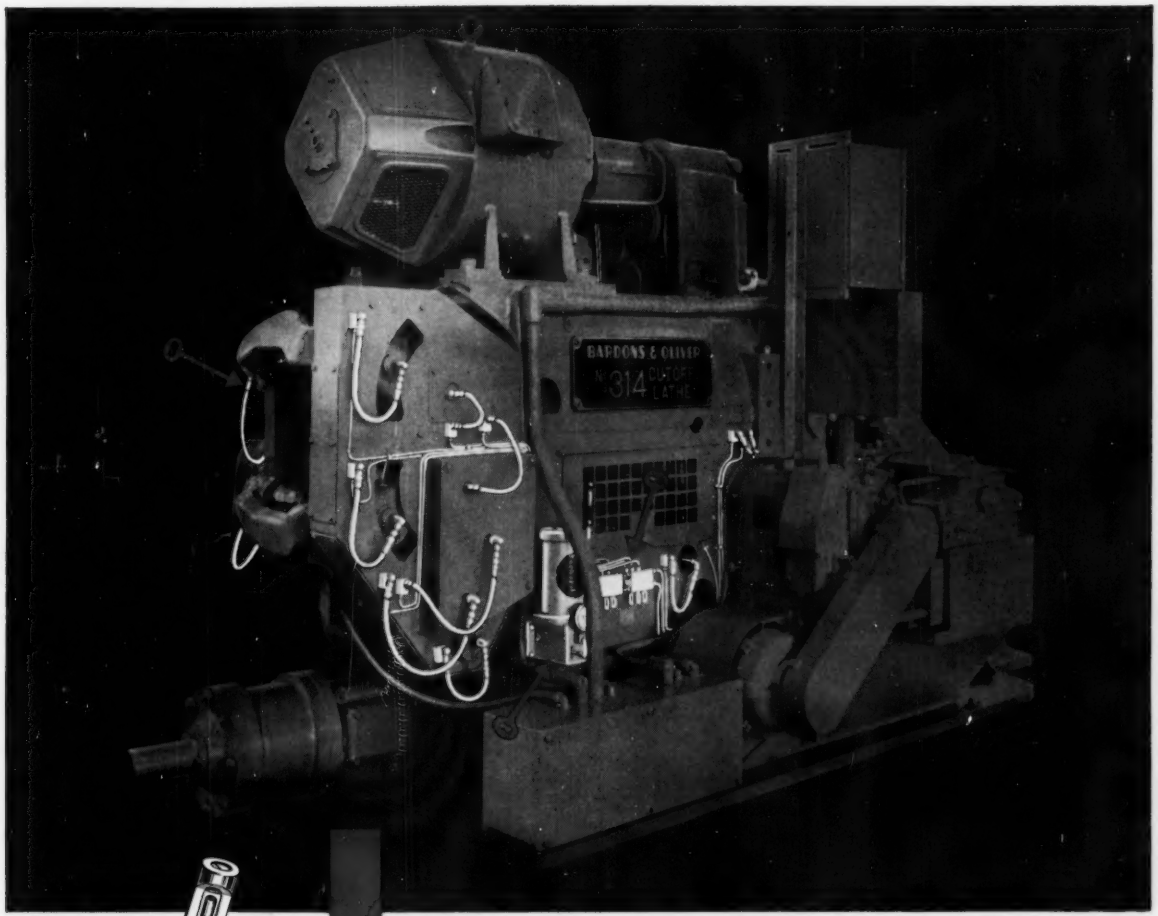
When you do your own machining, responsibility rests finally with you. The possibility of errors in dimensions, machining and tolerances, and of waste and delay suggest that you buy your laminated plastics from us and let us do the fabricating for you. Call any of our representatives—in principal cities—for a quotation or get in touch directly with Synthane Corp., 5 River Road, Oaks, Pa.

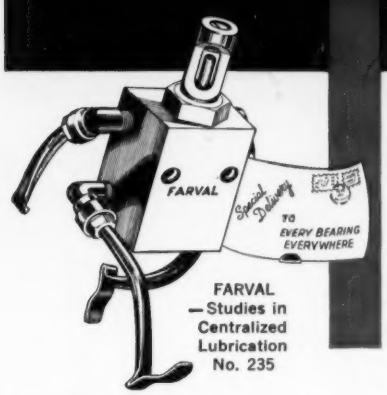
You furnish the print . . . we'll furnish the part

SYNTHANE
CORPORATION OAKS, PENNA.

Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

Circle 545 on Page 19





FARVAL
—Studies in
Centralized
Lubrication
No. 235

Farval lubrication keeps productivity high on cutting-off lathes

Cropping and chamfering steel tubing and pipe—as well as cutting-off and chamfering couplings ranging in diameter from 5 to 14½ inches—requires a heavy, rugged cut-off lathe like this Bardons & Oliver No. 314. It must be dependable in service—give high productivity—provide long trouble-free service life.

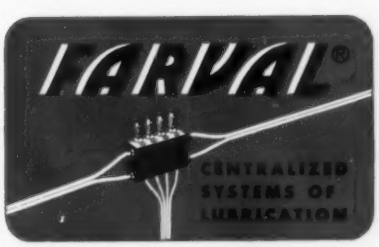
Bardons & Oliver design engineers chose a manually-operated Farval Dualine Centralized Lubrication System to serve the lathe's 39 vital bearings. During the last 7 years Farval has lubricated many of these B&O's—and there hasn't been a single known bearing failure to date!

Remember, a modern Farval system can adequately lubricate hundreds of bearings from one centrally-located pumping station. Why not check with your local Farval representative and see how these versatile lubrication systems can help produce superior, more productive industrial equipment. Or ask for your free copy of Bulletin 26-S—it contains the complete "Farval Story".

Farval Division • Eaton Manufacturing Company
3287 East 80th Street • Cleveland 4, Ohio

EATON

KEYS TO ADEQUATE LUBRICATION
—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.



Circle 402 on Page 19

Look what's behind Cutler-Hammer's new trademark

You can see the new power at Cutler-Hammer wherever you look. New products. New engineering depth, particularly in industrial automation. New plants and streamlined marketing methods, too. Even a new trademark to reflect this new vitality.

If you're planning ahead for the great growth of the sixties, come to the company that's ready to plan ahead with you. Look at just a few of the new products that are already improving efficiency in many fields:

NEW computer system for establishing quality of tinplate coils

NEW limit switch that outlasts others by at least two times

NEW automated system for charging blast furnaces in steel mills

NEW stacker that counts and stacks newspapers automatically

NEW Safetybreaker line of service entrance equipment

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

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Circle 403 on Page 19